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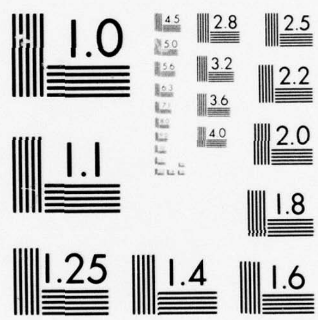
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Bethesda, Md. 20084

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DESIGN OF THE STERN CONTROL SURFACES AND PREDICTION OF THE MOTIONS OF THE DOLLY VARDEN BUOYANT RISE TEST VEHICLE

by

Richard M. Curphey

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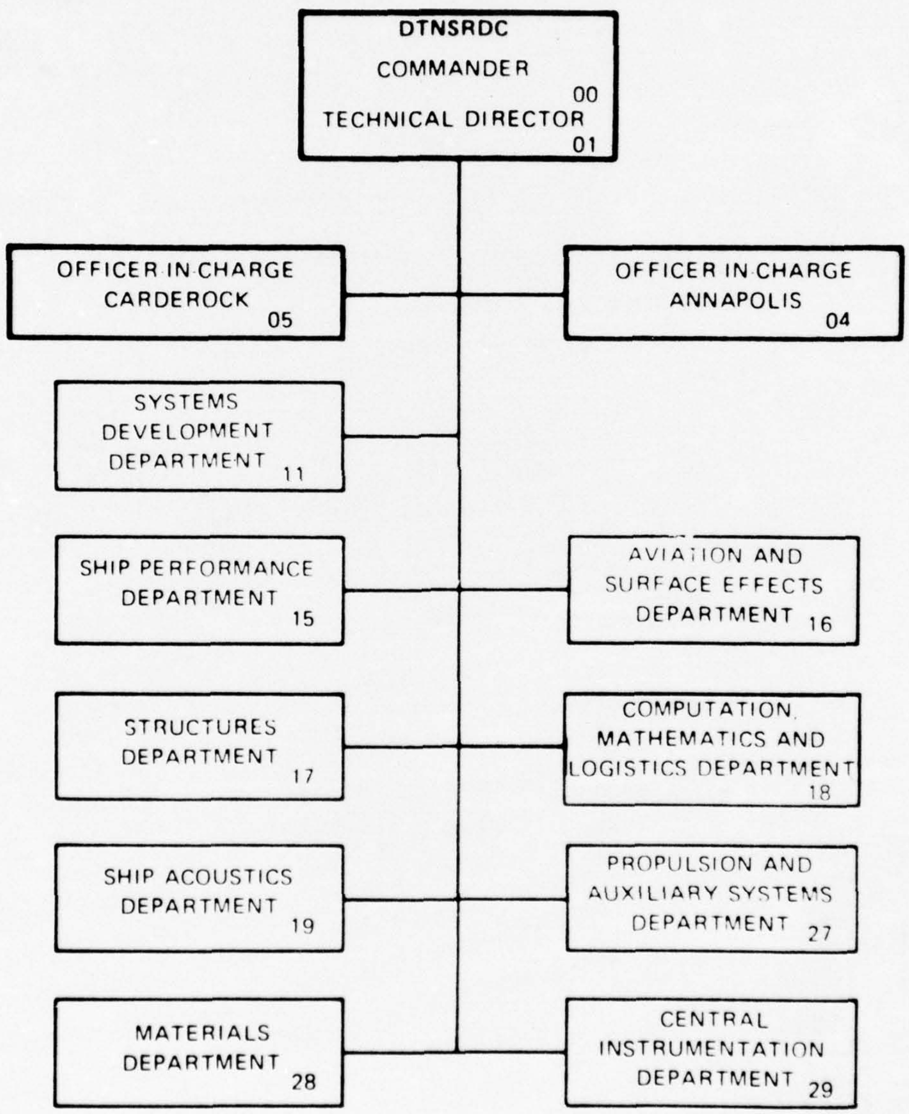

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The stern control surfaces of a 60-foot version of the DOLLY VARDEN Buoyant Rise Test Vehicle were designed from the standpoint of dynamic stability in vertical flight. Computer predictions were made of the vertical flight trajectories of the vehicle. It was found that a cruciform configuration of all-movable, retangular stern appendages with tip to tip span of 10 feet and chord length of 5 feet will provide adequate stability in vertical buoyant rise flight and required maneuverability for recovery. It was also determined that a net buoyancy of 20000 pounds would provide the required operational speed in vertical buoyant rise flight.

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NOTATION

AP	Aft perpendicular
B	Buoyancy
C_R	Residual resistance coefficient
C_F	Frictional resistance coefficient
D	Maximum diameter of body
G_n	Stability index
I_y, I_z	Moment of inertia about y and z axes, respectively
L	Length of body
LCB	Distance from nose to center of buoyancy
m	Mass of body
M, N	Moment about y and z axes, respectively
PMB	Parallel middlebody
q,r	Perturbation angular velocity about y and z axes, respectively
S_{TOT}	Total surface area of body
t	Time
u,v,w	Perturbation velocities in the x,y, and z directions, respectively
U	Equilibrium forward speed
V_K	Forward speed in knots
W	Weight
x,y,z	Right-handed Cartesian coordinates with origin fixed on the body axis at the center of buoyancy; positive x is directed forward along the longitudinal body axis

x_B, x_G	Longitudinal coordinates of centers of buoyancy and gravity, respectively, relative to x,y,z coordinate system
Y	Force in the y direction
z_B, z_G	Vertical coordinates of centers of buoyancy and gravity, respectively, relative to x,y,z coordinate system.
Z	Force in the z direction
Θ	Perturbation angular displacement about y axis
Θ_o	Equilibrium pitch angle relative to the horizontal
ν	Kinematic viscosity of water
ρ	Mass density of water
σ'_K	Nondimensional stability root

ABSTRACT

The stern control surfaces of a 60-foot version of the DOLLY VARDEN Buoyant Rise Test Vehicle were designed from the standpoint of dynamic stability in vertical flight. Computer predictions were made of the vertical flight trajectories of the vehicle. It was found that a cruciform configuration of all-movable, rectangular stern appendages with tip to tip span of 10 feet and chord length of 5 feet will provide adequate stability in vertical buoyant rise flight and required maneuverability for recovery. It was also determined that a net buoyancy of 20000 pounds would provide the required operational speed in vertical buoyant rise flight.

ADMINISTRATIVE INFORMATION

Predictions of the motions of the DOLLY VARDEN Buoyant Rise Test Vehicle were made for the Ship Acoustics Department of the David W. Taylor Naval Ship R&D Center in accordance with memorandum 1946:JS:DN of 13 February 1976.

INTRODUCTION

The Ship Performance Department of the David W. Taylor Naval Ship R&D Center (DTNSRDC) was requested by the Ship Acoustics Department to provide assistance in developing the general arrangements, designing the control surfaces, and predicting the motions and trajectories of the DOLLY VARDEN, Buoyant Rise Vehicle, a newly designed acoustic test vehicle similar to the KAMLOOPS. Although the DOLLY VARDEN may eventually operate in powered, submerged horizontal flight, it will be initially used as a buoyant rise vehicle, and will be required to ascend with the longitudinal axis in a nearly vertical orientation or attitude.

It is intended that the vehicle be given a specified net buoyancy and released from far below the surface with an initially vertical attitude. The vehicle will accelerate upward rapidly and must attain a specified speed of 40 knots at a depth of 400 feet. At 200 feet below the surface, a recovery maneuver is to be initiated. It is anticipated that the sternplanes would be deflected, thus turning the vehicle from a nearly vertical flight to a more nearly horizontal flight path with a consequent slowing of its forward speed. During the vertical portion of the flight, it is also required that deviation in the vehicle attitude from the vertical and the horizontal displacement from the launch point not be excessive.

An analysis of the dynamic behavior of the DOLLY VARDEN in vertical buoyant rise flight is presented in this report. Hydrodynamic coefficients for the buoyant rise vehicle have been estimated, and the vertical flight dynamic stability has been examined as a function of net buoyancy and center of gravity location. A set of stern appendages is recommended to provide acceptable stability and maneuverability.

The motion, trajectory, and speed of the vehicle during the vertical flight and proposed recovery maneuver have been determined using the submarine motion computer simulation program ZZMN. The effect of amount of net buoyancy is examined. In addition, the influence of the maximum sternplane angle and rate of deflection on the recovery maneuver is investigated.

GEOMETRIC CHARACTERISTICS

The DOLLY VARDEN is a large test vehicle roughly similar in external appearance to the Navy's modern attack submarines. The vehicle is a body of revolution with typical forebody, parallel middlebody, and afterbody, and with cruciform tail appendages the size and shape of which are dependent upon stability and maneuverability considerations. For the buoyant rise configuration, there is no propeller or bridge fairwater.

The length of the vehicle is approximately 60 feet with a 23-foot parallel middlebody section. In the future the parallel middlebody may be extended to accommodate a propulsion unit. However, it should be emphasized that the analysis presented here will apply only to the 60-foot version.

Figure 1 shows the outline of the bare hull of DOLLY VARDEN. Dimensions are as provided by the DTNSRDC Ship Acoustics Department. Table 1 shows various geometrical characteristics of the bare hull.

The weight and longitudinal location of the center of gravity are treated as independent variables in the analysis. In the vertical attitude, the desired upward acceleration of the vehicle is produced by a net difference between the buoyancy and weight, the magnitude of which affects

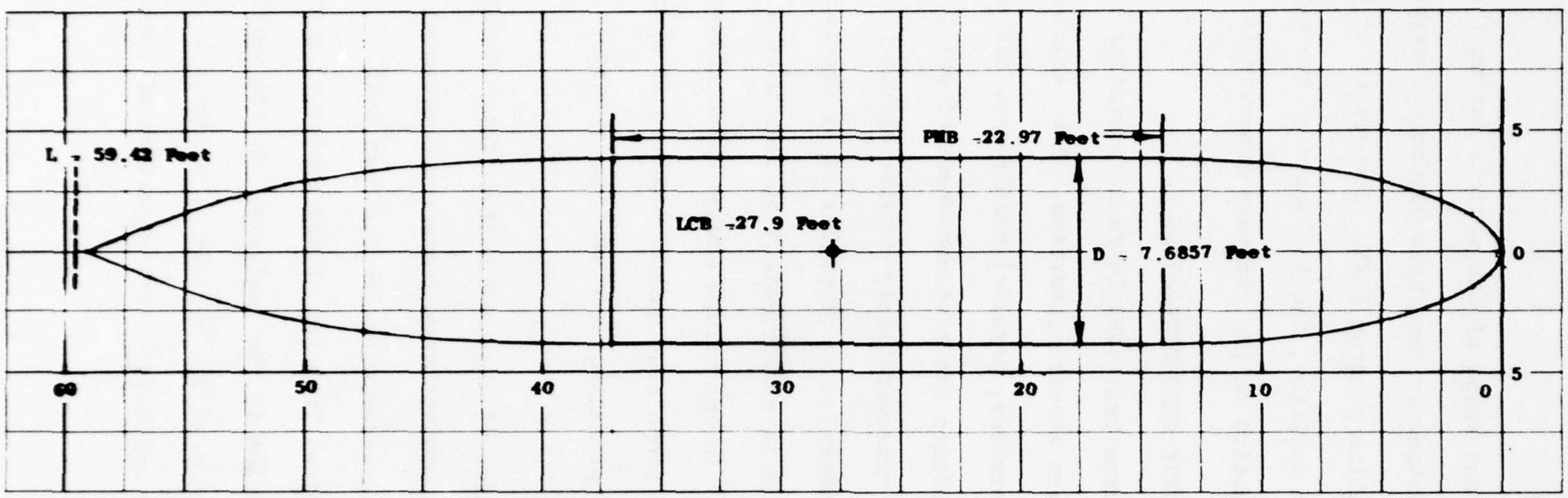

Figure 1 - Profile of the Bare Hull DOLLY VARDEN

Table 1 - Geometric Characteristics of the DOLLY VARDEN (Bare Hull)

Characteristic	Value
Length	59.42 feet
Diameter (Maximum)	7.6857 feet
Length: Nose	14.090 feet
PMB	22.972 feet
Afterbody	22.358 feet
Volume	2125 $feet^3$
Wetted Surface Area	1195 $feet^2$
Longitudinal Center of Buoyancy (from nose)	27.9 feet
Vertical Center of Buoyancy	0.0 feet
Mass, Neutral Buoyancy	4.120×10^3 slugs*
Buoyancy	1.326×10^5 pounds**
Longitudinal Moment of Inertia	0.75×10^6 slug-$feet^2$

* Mass density of freshwater at 4 degrees C. ($\rho = 1.937$ slugs/$feet^3$)

** Acceleration due to gravity ($g = 32.175$ feet/ sec^2)

both speed and stability. The center of gravity is generally located aft of the center of buoyancy in order to provide stability in vertical flight. In the analysis, the net upward buoyancy ranges from 16,000 to 24,000 pounds and the center of gravity is located 1.5 to 2.5 feet aft of the center of buoyancy.

The stability characteristics of a neutrally buoyant configuration with centers of buoyancy and gravity coincident are also investigated, since this condition might be obtained for a zero trim, neutrally buoyant vehicle in powered horizontal flight.

The center of gravity of a submarine would normally be displaced from the axis of symmetry in order to provide static stability in roll and pitch. In the present analysis, however, the effect of this displacement of the center of gravity has not been considered and it is assumed to lie on the body longitudinal axis of symmetry in all cases.

The moment of inertia of the vehicle in pitch depends on the ballast conditions. However, the differences in the actual ballast conditions investigated occur near the middle of the vehicle, and thus their effect on the moment of inertia is minimal. The value of the moment of inertia used in the analysis was computed for the 16,000 pound net buoyant vehicle with uniform mass distribution, and was assumed to be the same for all other ballast conditions.

DYNAMIC STABILITY AND DESIGN APPENDAGES

The sizes of the stern appendages for the DOLLY VARDEN are based upon requirements for adequate stability and maneuverability of the vehicle

in vertical buoyant rise flight. The linear, vertical plane equations of motion are given in Appendix A, and the dynamic stability characteristics of the vehicle configurations having a range of appendage chord lengths and ballast conditions are obtained from the roots of the governing characteristic equations. It is assumed that the body is initially in steady straight-line flight, moving in a purely forward direction with speed U at an angle θ_o relative to the horizontal as shown in Figure 2. The coupled normal force and pitch moment equations for small perturbations from the equilibrium condition of steady flight are given by Equations (A-1) and (A-2) of Appendix A, respectively, and the characteristic equation corresponding to the vertical plane motion is a cubic of the form

$$A\sigma_K'^3 + B\sigma_K'^2 + C\sigma_K' + D = 0 \tag{1}$$

where σ_K' is the nondimensional root, and the coefficients are defined by Equations (A-6) through (A-9).

Of particular interest is the condition where the vehicle is moving vertically upward. The metacentric derivatives Z_θ' and M_θ' given by Equations (A-3) and (A-4), respectively, for θ_o = 90 degrees are evaluated in Table 2 for several combinations of the net buoyancy and longitudinal center of gravity, x_G. Since the nondimensional metacentric derivatives are speed dependent, the values indicated in Table 2 have been multiplied by the square of the speed in knots. A negative x_G indicates that the center of gravity is aft of the center of buoyancy.

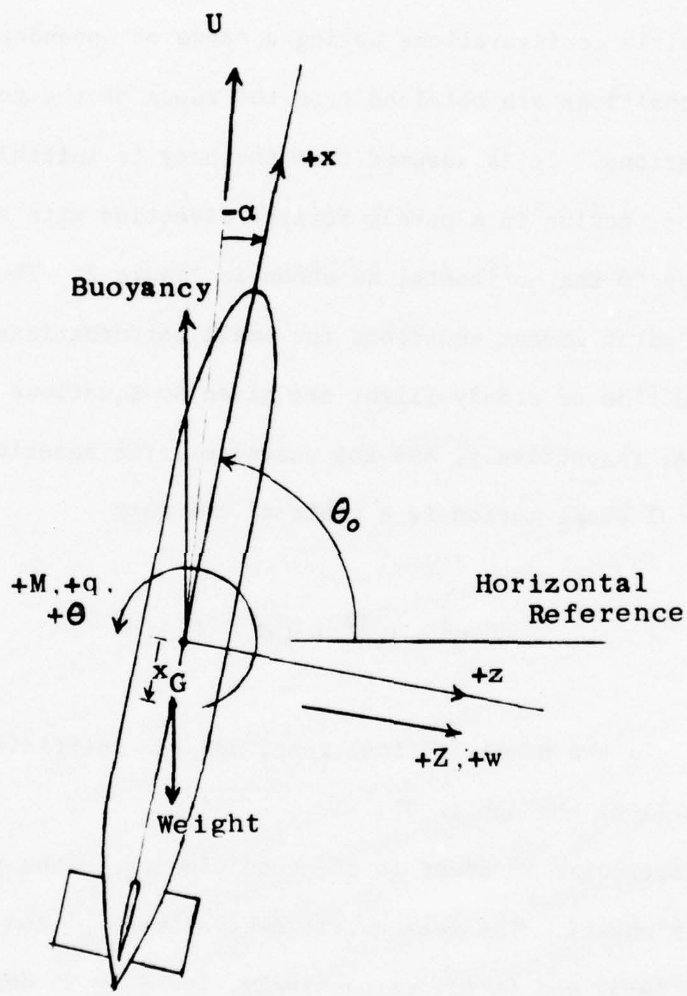

Figure 2 - Definition Sketch of Problem Geometry

Table 2 - Ballast Conditions and Metacentric Derivatives

Net Buoyancy in pounds	Weight in pounds	$\frac{\text{Mass}}{\frac{1}{2}\rho L^3}$	$Z'_\theta V_k^2$ in knots^2 *	x_G in feet	$M'_\theta V_k^2$ in knots^2 *
16000	1.166×10^5	0.01782	1.6385	-1.5 -2.0 -2.5	-0.3014 -0.4019 -0.5023
20000	1.126×10^5	0.01721	2.0482	-1.5 -2.0 -2.5	-0.2911 -0.3881 -0.4852
24000	1.086×10^5	0.01659	2.4578	-1.5 -2.0 -2.5	-0.2807 -0.3743 -0.4678

* θ_o = 90 Degrees

A cruciform appendage configuration with tip to tip span of 10 feet was specified, and for simplicity of construction, all-movable, rectangular appendages were preferred. The trailing edges of the appendages were fixed at 56.6 feet aft of the nose and the effect of appendage chord length variation on the vehicle dynamic stability was investigated over the range of ballast conditions indicated in Table 2.

The hydrodynamic stability derivatives for vehicle configurations with 3, 4, 5, 6, 7 and 8-foot chord appendages have been estimated. These stability derivatives in nondimensional form are given in Table 3 and follow the notations and conventions of Reference 1. The DOLLY VARDEN is geometrically symmetric relative to the longitudinal axis, hence the values for the vertical plane derivatives also correspond to the horizontal plane derivatives indicated in parentheses. A sketch of the 5-foot chord appendage is shown in Figure 3.

The roots of the characteristic equation σ'_K determine the nature of the vertical plane motion. For the vehicle configuration with 5-foot chord appendages, the characteristic equations corresponding to the ballast conditions of Table 2 are provided in Table 4, where V_K is the speed in knots and the appropriate metacentric and hydrodynamic derivatives are given from Tables 2 and 3, respectively. The equations in Table 4 have been divided by the coefficient of the cubic term A which is positive and relatively unchanged in all cases.

The nondimensional stability roots σ'_K are shown in Figure 4 for the 5-foot chord configuration with net buoyancy of 16,000 pounds, and center of gravity x_G = -1.5 feet. The symbol Re σ'_K denotes the real roots,

Table 3 - Stability Derivatives for the DOLLY VARDEN

Coefficient*	Chord Length in feet					
	3	4	5	6	7	8
Z'_w (Y'_v)	-.02575	-.02814	-.02973	-.03083	-.03159	-.03215
M'_w $(-N'_v)$	+.006814	+.006096	+.005664	+.005483	+.005466	+.005553
Z'_q $(-Y'_r)$	-.01111	-.01182	-.01226	-.01244	-.01246	-.01237
M'_q (N'_r)	-.005267	-.005454	-.005516	-.005477	-.005369	-.005217
$Z'_{\dot{w}}$ $(Y'_{\dot{v}})$	-.02068	→	→	→	→	→
$M'_{\dot{w}}$ $(-N'_{\dot{v}})$	0.0	→	→	→	→	→
$Z'_{\dot{q}}$ $(-Y'_{\dot{r}})$	0.0	→	→	→	→	→
$M'_{\dot{q}}$ $(N'_{\dot{r}})$	-.001473	→	→	→	→	→

* For definition of nondimensional coefficient, see Reference 1.

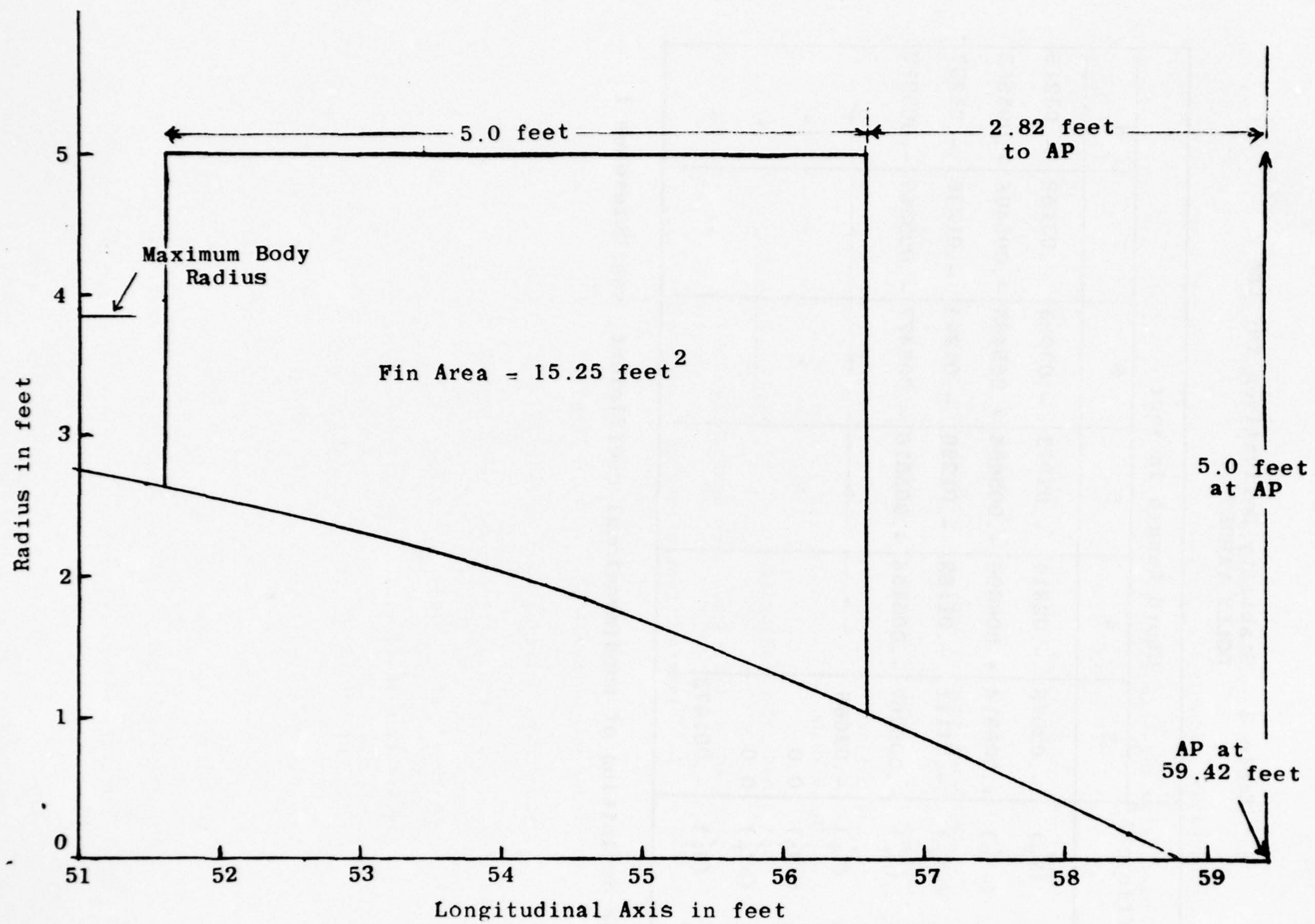

Figure 3 - Proposed Stern Appendage for the DOLLY VARDEN

Table 4 - Vertical Plane Characteristic Equations for the DOLLY VARDEN with 5-Foot Chord Appendages

$\sigma_k'^3 + (B/A)\sigma_k'^2 + (C/A)\sigma_k' + (D/A) = 0$ V_k = Speed in knots

Net Buoyancy in pounds	Center of Gravity in feet	B/A	C/A	D/A
16000	-1.5	2.559	$1.062 + 110.086/V_k^2$	$-\ 2.853/V_k^2$
	-2.0	2.526	$1.024 + 147.001/V_k^2$	$+23.833/V_k^2$
	-2.5	2.494	$0.986 + 184.056/V_k^2$	$+50.589/V_k^2$
20000	-1.5	2.573	$1.115 + 108.028/V_k^2$	$-26.705/V_k^2$
	-2.0	2.540	$1.078 + 144.221/V_k^2$	$-\ 0.570/V_k^2$
	-2.5	2.501	$1.133 + 180.609/V_k^2$	$+25.672/V_k^2$
24000	-1.5	2.589	$1.174 + 106.821/V_k^2$	$-50.741/V_k^2$
	-2.0	2.556	$1.133 + 141.347/V_k^2$	$-25.765/V_k^2$
	-2.5	2.525	$1.097 + 176.942/V_k^2$	$-\ 0.123/V_k^2$

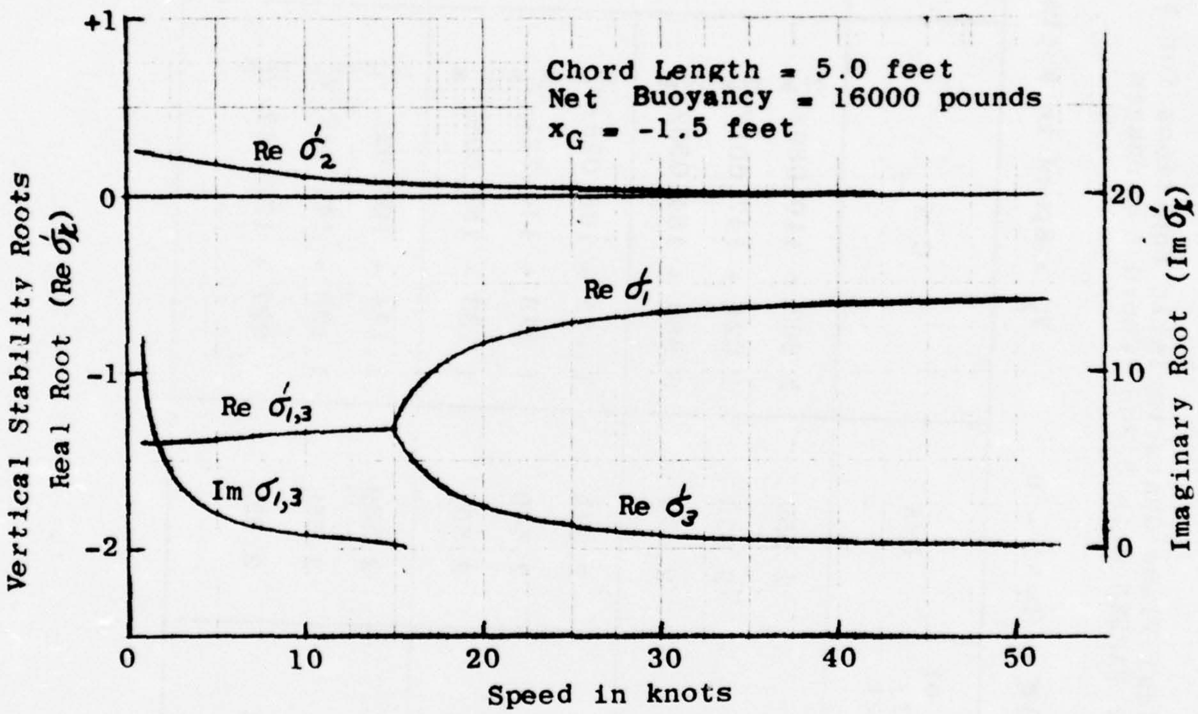

Figure 4 - Stability Roots for Vertical Buoyant Rise Flight

Re $\sigma'_{1,3}$ denotes the real part of the complex root, and Im $\sigma'_{1,3}$ denotes the imaginary part of the complex root. For speeds less than 15 knots, there is a positive real root indicating a divergent path and a pair of complex roots with negative real part indicating that the response is oscillatory. For speeds above 15 knots, all of the roots are real, and one of the roots is positive indicating a nonoscillatory divergent response for the vehicle. The small positive real root σ'_2 means that the pitch motion is unstable at all speeds for the particular appendage and ballast condition indicated. At higher speeds, the positive root approaches zero. It will be seen later that the small positive root plays a minor role in the trajectories of the vehicle. The stability analysis is not strictly valid in the very low speed range where the vehicle is accelerating rapidly. Simulation of the trajectories indicates the vehicle is actually stable at and immediately following launch, but then has essentially the stability characteristics shown in Figure 4 as the vertical acceleration decreases.

The DOLLY VARDEN will be operating primarily in the high speed range, and the very small value of the unstable root Re σ'_2 is not expected to significantly influence the vehicle trajectory. Hence, the effect of variation of appendage chord length and ballast condition on the stability characteristics at infinite speed will be investigated.

At infinite speed Equation (1) reduces to a quadratic of the form

$$A\sigma'^2_K + B\sigma'_K + C_O = 0 \qquad (2)$$

where the coefficients are given by Equations (A-6), (A-7), and (A-12). A necessary and sufficient condition for stability is that all of the coefficients of Equation (3) be positive. For the range of ballast conditions and chord lengths indicated in Tables 2 and 3, respectively, the coefficients

A and B are positive and remain relatively unchanged (See Table 4). The infinite speed stability condition then requires that the coefficient C_o (Equation A-12) be greater than zero. The infinite speed stability index G_n is given by Equation (A-14), where $G_n > 0$ denotes stability and a larger value of G_n denotes a greater degree of stability.

In Figure 5, the stability index is plotted as a function of chord length for values of the net buoyancy corresponding to 16, 20, and 24 thousand pounds. The stability index is relatively insensitive to center of gravity location, hence these values are given only for $x_G = -2.0$ feet. A change of 0.5 feet in the x_G produces no more than a 2 percent change in G_n over the range of chord length and net buoyancy conditions shown, where, as can be seen from Equation (A-14), a shift of the center of gravity aft would tend to reduce the stability index and a shift forward would increase the stability index.

Figure 5 indicates that the DOLLY VARDEN is dynamically stable at infinite speed for all of the appendage and ballast conditions shown, however, a chord length greater than approximately 5 feet provides little additional stability.

Also shown in Figure 5 is the stability index for the neutrally buoyant vehicle with the centers of buoyancy and gravity coincident. This condition also provides the horizontal stability characteristics of a zero trim, neutrally buoyant, 60-foot vehicle in powered, horizontal flight.

The dynamic stability characteristics of the DOLLY VARDEN at finite speeds will now be investigated. Figure 4 indicates that for the 5-foot chord length vehicle configuration with net buoyancy of 16,000 pounds and $x_G = -1.5$ feet, a small positive real root is obtained which causes

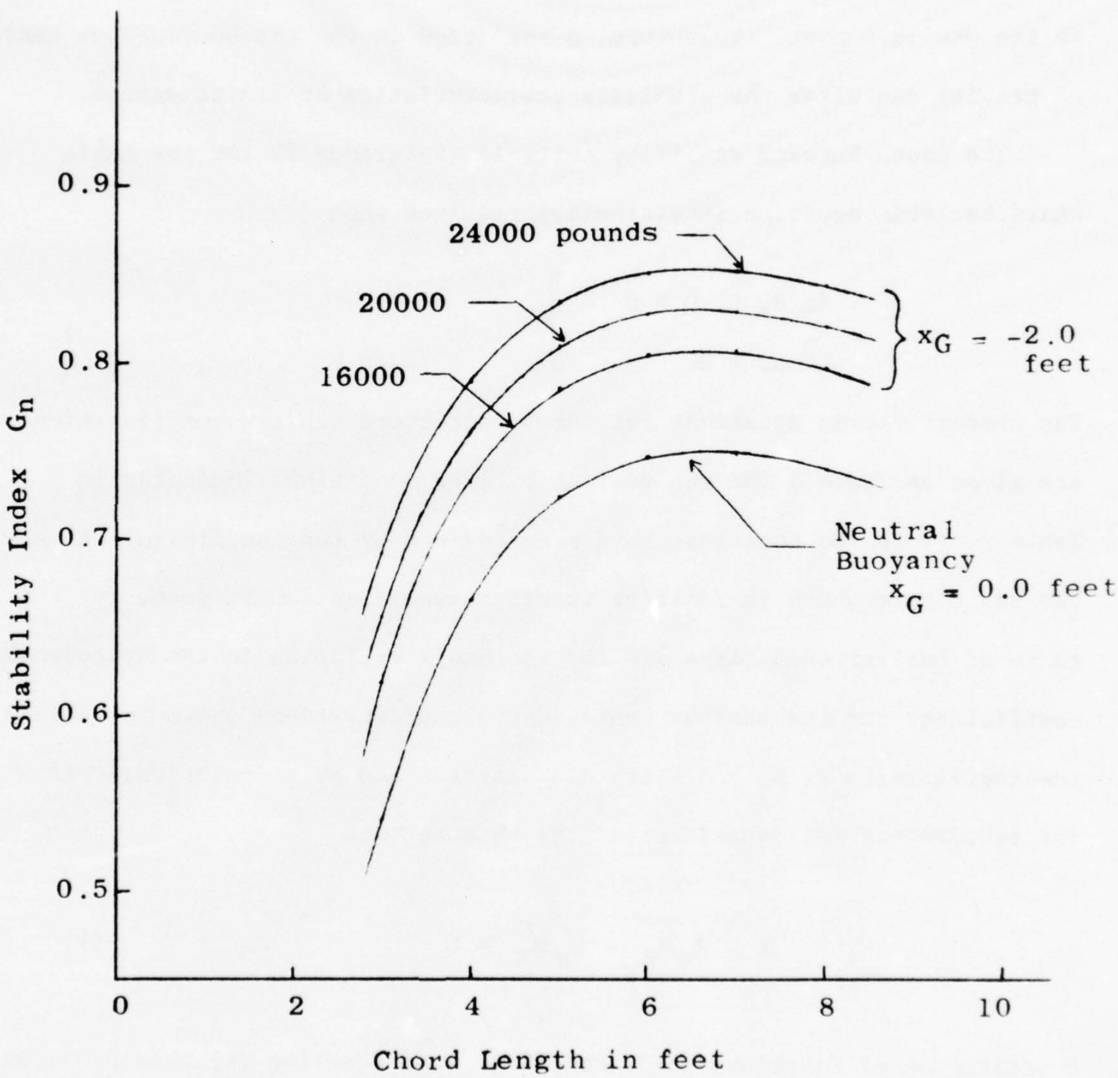

Figure 5 - Stability Index for the DOLLY VARDEN at Infinte Speed

the vehicle to be unstable at finite speeds. Since this real root approaches zero as the speed becomes large, it is clear from Equations (A-3) through (A-9) and Table 4 that the metacentric effects result in the unstable root. Therefore, a variation in the net buoyancy or center of gravity can alter the stability characteristics at finite speeds.

The Routh-Hurwitz stability criteria (Reference 2) for the cubic characteristic equation (Equation(1)) requires that

$$\left.\begin{aligned} &A,\ B,\ C,\ D > 0 \\ &BC-AD > 0 \end{aligned}\right\} \qquad (3)$$

The characteristic equations for the 5-foot chord vehicle configuration are given in Table 4 for the various ballast conditions indicated in Table 2. (Note the equations have been divided by the coefficient A of the cubic term which is positive in all cases.) As can be seen, for this range of ballast conditions and for the small variation in the hydrodynamic coefficients for the various chord length configurations shown in Table 3 the coefficients A, B, and C are all positive and by calculation, $BC-AD>0$. The requirement for dynamic stability then becomes

$$D = Z'_w M'_\theta - Z'_\theta M'_w > 0 \qquad (4)$$

Substitution of Equations (A-3) and (A-4) into Equation (4) then provides the following condition for vertical stability at finite speeds within the range of ballast and appendage configurations considered

$$\frac{L(W-B)}{x_G W} < \left|\frac{Z_w'}{M_w'}\right| \qquad (5)$$

where L is the vehicle length and (W-B) is the weight minus buoyancy.

Equation 5 indicates that increasing net buoyancy tends to be a destabilizing effect while movement of the center of gravity aft stabilizes the vehicle. The combinations of net buoyancy and center of gravity which provide dynamically stable motion at finite speeds are shown in Figure 6 for three values of the appendage chord length. The region above a given curve denotes stability and region below denotes instability.

Figure 6 indicates that only marginal improvement in the range of dynamically stable ballast conditions is obtained as the appendage chord length is increased from 5 to 7 feet. Therefore, based upon the infinite speed stability characteristics shown in Figure 5, the 5-foot chord appendage appears to provide nearly optimum stability with a minimum of drag. It should be noted from Figure 6 that there will be certain ballast conditions for which the 5-foot chord vehicle configuration is unstable, however, it will be shown in the following section that the instability is so weak that the pitch angle and vehicle trajectory are not significantly affected over the distance of vertical travel. Furthermore, a small instability would tend to improve the response during the recovery maneuver.

MOTION AND TRAJECTORY

In the previous section, it was shown that a 5-foot chord appendage configuration provides dynamic stability at infinite speed for the DOLLY VARDEN in vertical buoyant rise flight, although a very weak

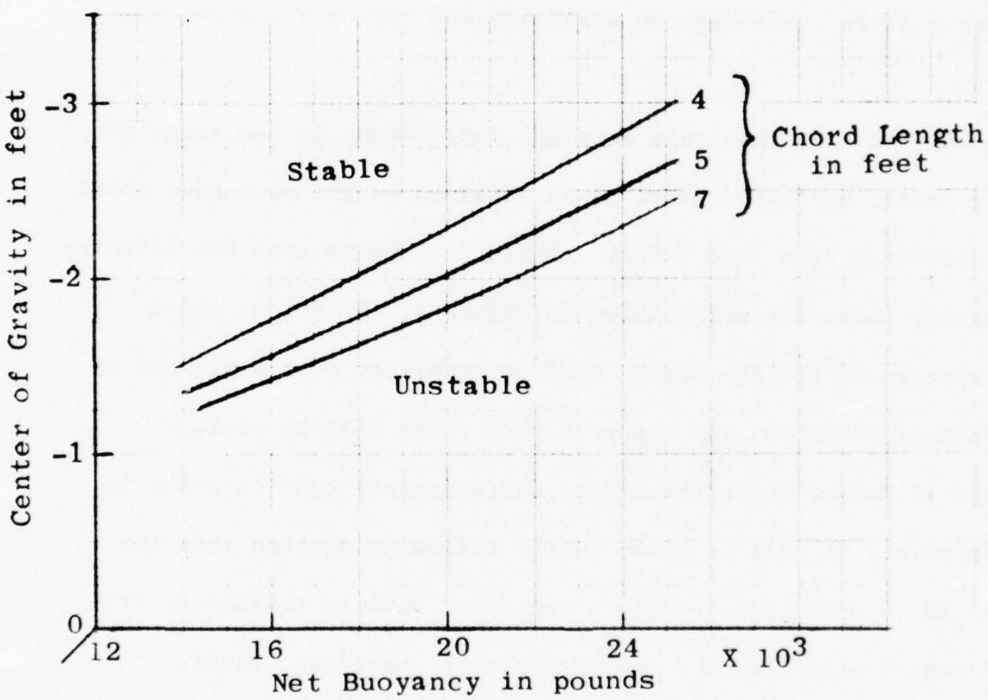

Figure 6 - Effect of Ballast on Vertical Stability at Finite Speed

instability is present for some ballast conditions at the lower speeds. In this section the vertical plane motion of the 5-foot chord vehicle during vertical flight and the proposed recovery maneuver is investigated by performing computer simulations with the program ZZMN.

The computer program, ZZMN, is a time domain simulation essentially based upon the nonlinear equations of motion given in Reference 1. The coefficients given in Table 3 for the 5-foot chord configuration have been used in the simulation with the exception that the static derivatives Z_w' and M_w' have been replaced by a nonlinear fit for the static force and moments, the coefficients of which are provided in Table 5. The vertical plane equations used in the simulation are provided in Appendix C.

Since the vehicle initially starts from rest and accelerates to a high speed, the computer program has been modified to include a speed dependent drag coefficient. The drag is given by

$$\text{Drag} = 1/2\rho(C_F + C_R)S_{TOT}U^2$$

where S_{TOT} is the total wetted surface area. The frictional resistance coefficient, C_F, is given by the ITTC curve (Reference 3)

$$C_F = \frac{0.075}{(\log_{10}Re_L - 2)^2}$$

where $$Re_L = UL/\nu \; .$$

The residual resistance coefficient, C_R, was estimated for the 5-foot chord appendages, and for $S_{TOT} = 1317 \text{ feet}^2$, $C_R = 0.000285$

Table 5 - Nonlinear Static Coefficients for the DOLLY VARDEN

Chord Length = 5.0 feet

$Z'_w = -0.02476$	$M'_w = +0.006853$
$Z'_{w\|w\|} = -0.09560$	$M'_{w\|w\|} = -0.02249$

Figures 7 and 8 show the velocity and pitch angle, respectively, attained at a depth of 200 and 400 feet as a function of the net buoyancy. The initial depth is 1,000 feet, the initial pitch angle is 89 degrees, and the center of gravity location is 1.5 feet aft of the center of buoyancy. Figure 7 shows, as expected, that an increase in the net buoyancy results in greater speed. The required 40-knot speed at the 400-foot depth is obtained with a net buoyancy slightly greater than 20,000 pounds. Figure 8 shows that the deviation of the pitch angle from the initial condition increases with distance traveled and increasing net buoyancy. This is a result of the weak dynamic instability mentioned in the previous section for the particular ballast condition. The pitch deviation from the vertical, however, is less than 2 degrees.

Figure 9 shows the pitch angle and depth responses during the recovery maneuver for a vehicle configuration with net buoyancy of 20,000 pounds and $x_G = -1.5$ feet. The sternplanes are deflected to 15 degrees at a rate of 30 degrees/second when a depth of 200 feet is attained. At the instant the planes are deflected, the elapsed time after launch is 18.9 seconds, the speed is 42.4 knots, and the pitch angle is 88.4 degrees. At an elapsed time of 23.2 seconds after launch, the pitch angle is zero (body is horizontal). At this instant, the depth is 5 feet, the forward speed is 23.4 knots, and the upward velocity is 9.2 feet/second.

Figure 9 shows various trajectory parameters for the vehicle calculated with the initial depth set in the simulation at a value of 5000 feet and the depth at the end of a trajectory given as the number of feet

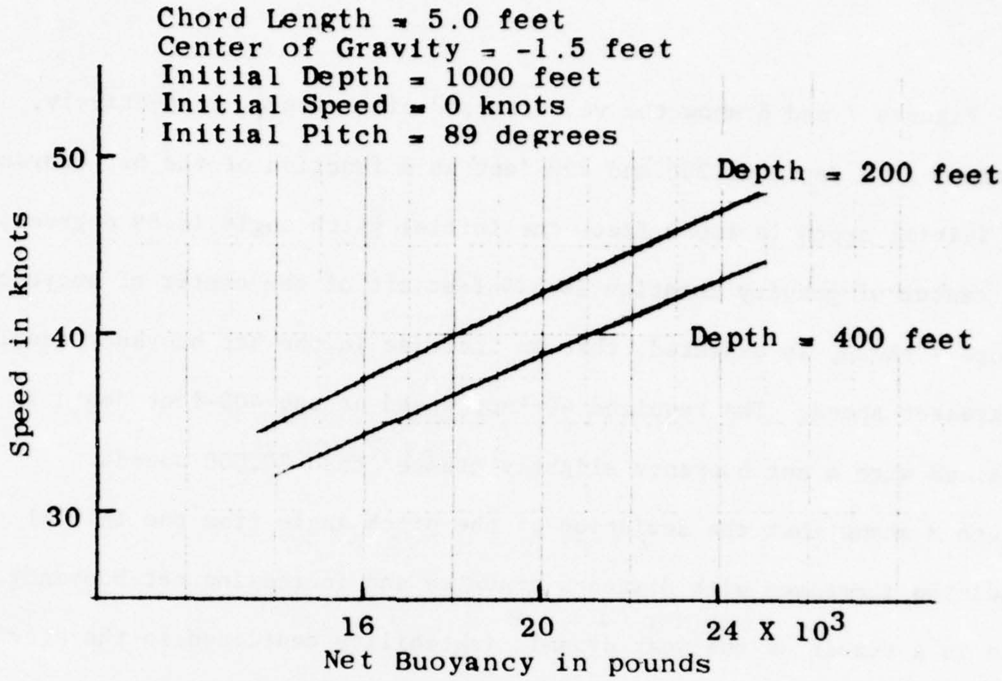

Figure 7 - Effect of Net Buoyancy on Speed During Vertical Flight

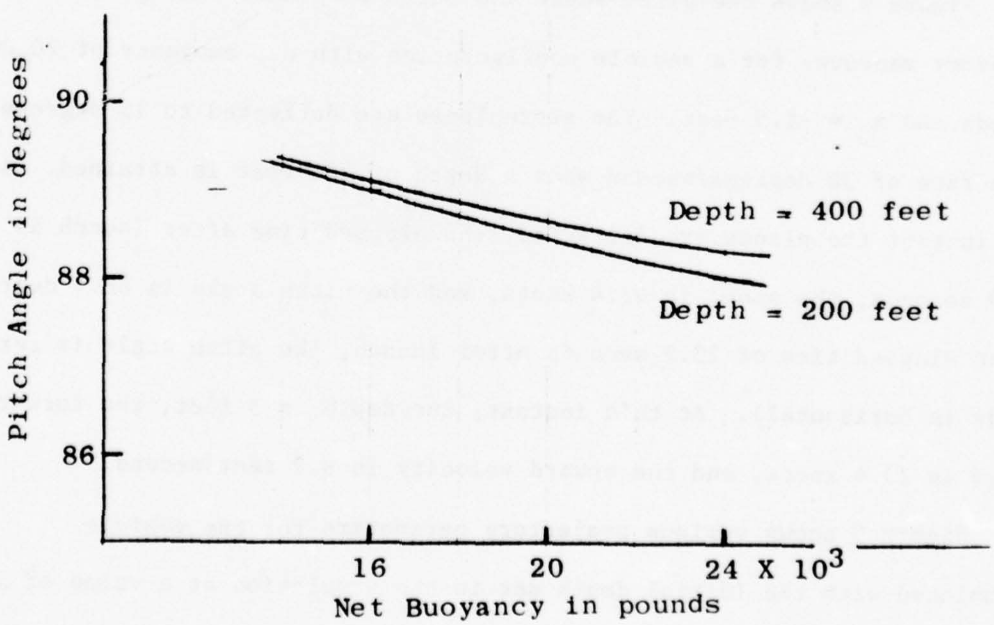

Figure 8 - Effect of Net Buoyancy on Pitch Angle During Vertical Flight

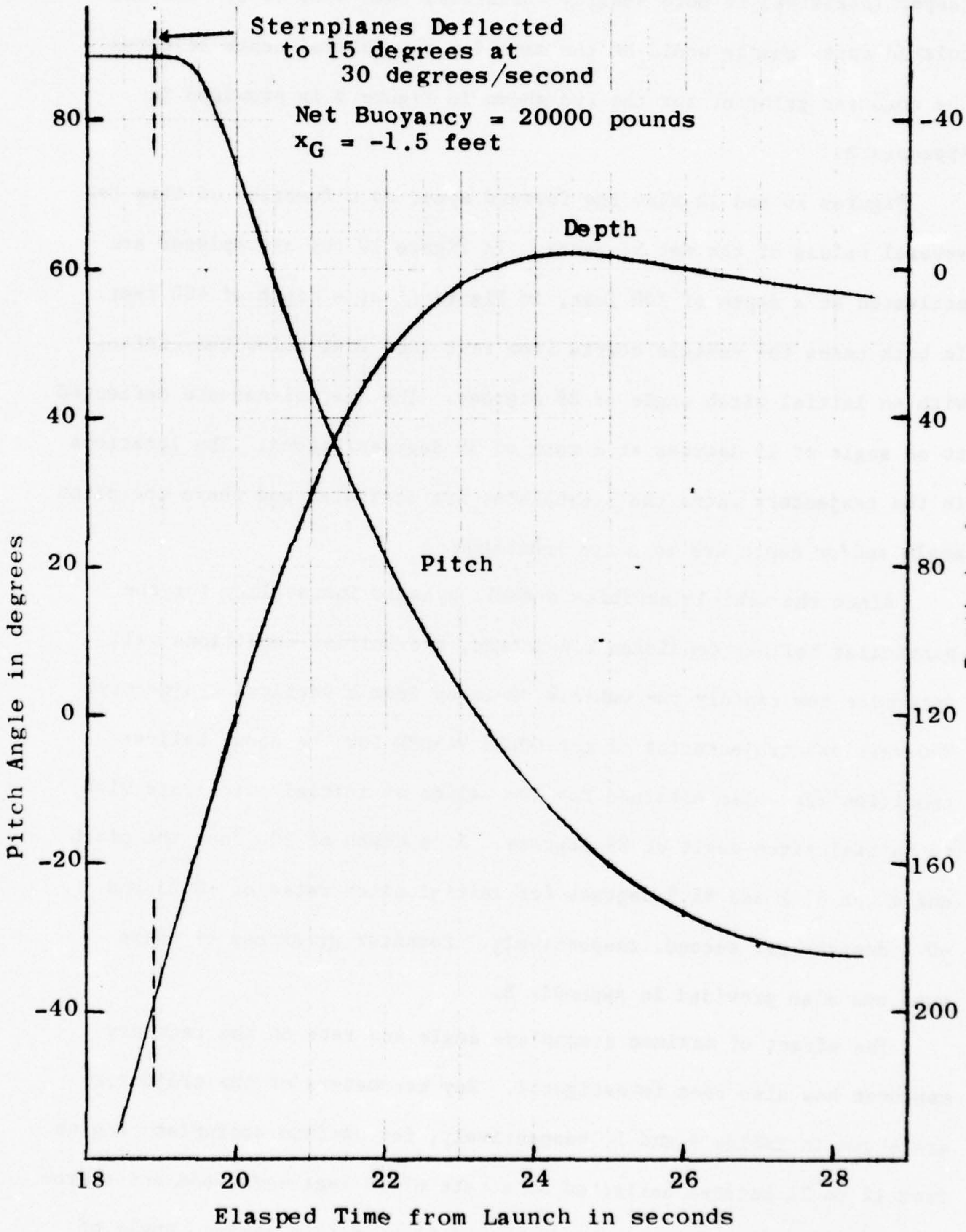

Figure 9 - Pitch and Depth Trajectories During Recovery Maneuver

deeper (positive) or more shallow (negative) than 4000 feet. The calculated depth change would be the same for any initial depth selected. The computer printout for the run shown in Figure 9 is provided in Appendix B.

Figures 10 and 11 show the forward speed as a function of time for several values of the net buoyancy. In Figure 10 the sternplanes are activated at a depth of 200 feet, in Figure 11 at a depth of 400 feet. In both cases the vehicle starts from rest 1000 feet below the surface with an initial pitch angle of 89 degrees. The sternplanes are deflected to an angle of 15 degrees at a rate of 30 degrees/second. The locations in the trajectory where the sternplanes are activated and where the pitch angle and/or depth are zero are indicated.

Since the vehicle exhibits a small dynamic instability for the particular ballast condition considered, the initial conditions will determine how rapidly the vehicle deviates from a vertical trajectory. The vertical trajectories of the DOLLY VARDEN for the above ballast condition were also obtained for two values of initial pitch rate with an initial pitch angle of 89 degrees. At a depth of 200 feet the pitch angle was 87.2 and 85.9 degrees for initial pitch rates of -0.25 and -0.5 degrees per second, respectively. Computer printouts of these runs are also provided in Appendix B.

The effect of maximum sternplane angle and rate on the recovery maneuver has also been investigated. Key parameters of the trajectory are shown in Tables 6 and 7, respectively, for maximum sternplane angles from 12 to 21 degrees deflected at a rate of 30 degrees/second, and sternplane rate of 7.5 to 75 degrees/second deflected to a maximum angle of 15 degrees. The planes are deflected at a depth of 4200 feet or 18.9

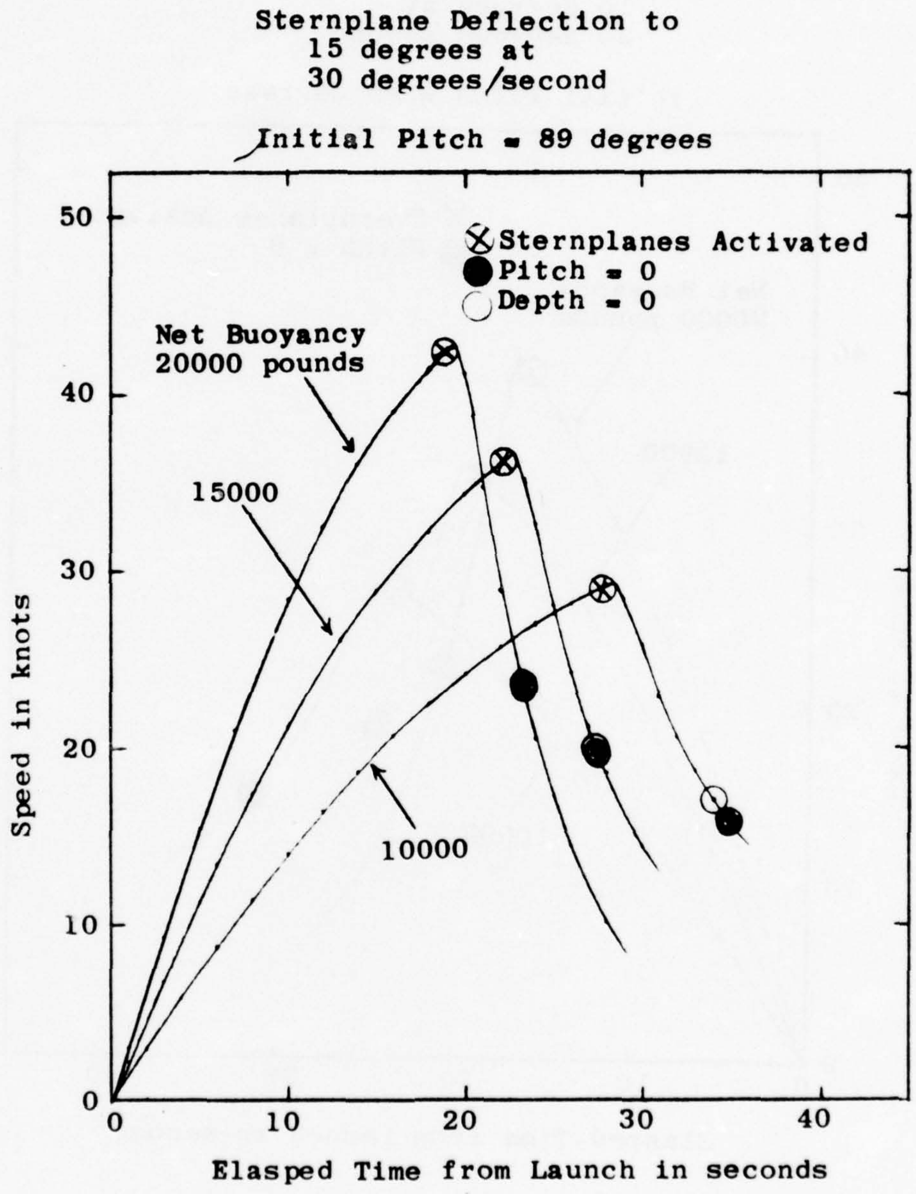

Figure 10 - Velocity Trajectories for Recovery Maneuver Initiated at 200 Feet

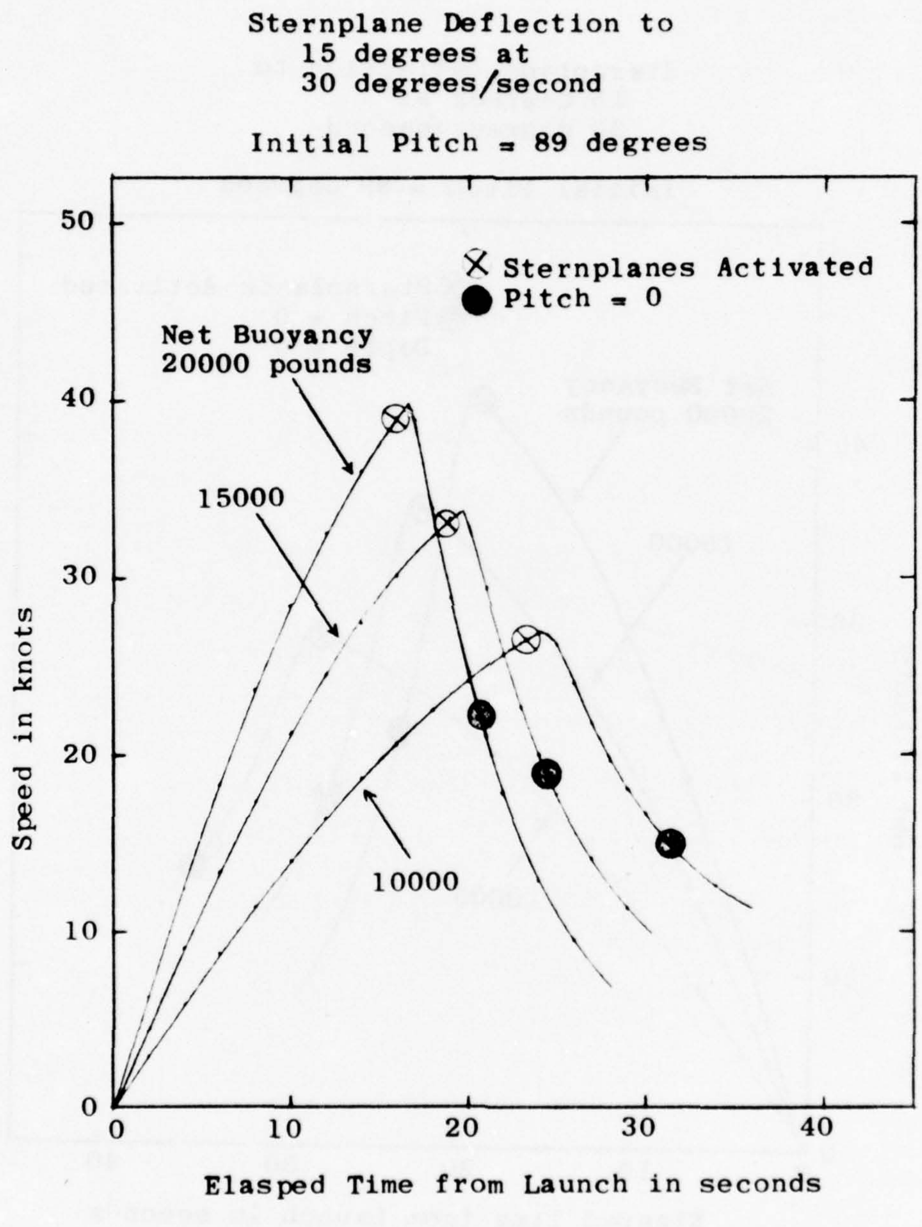

Figure 11 - Velocity Trajectories for Recovery Maneuver Initiated at 400 Feet

Table 6 - Trajectory Parameters for Sternplane Deflection Angle Variation
Deflection Rate - 30 Degrees/second

Trajectory Parameters	Maximum Sternplane Deflection Angle in degrees			
	12	15	18	21
Elasped time in seconds from launch to:				
Zero Pitch	23.7	23.2	22.9	22.7
Zero Depth	22.4	23.4	-	-
Speed in knots at:				
Zero Pitch	25.6	23.4	21.4	19.7
Zero Depth	30.6	22.8	-	-
Depth in feet at:				
Zero Pitch	-22.0	1.4	17.0	28.0
Pitch in degrees at:				
Zero Depth	20.1	-2.5	-	-
Upward vertical velocity in feet/sec at:				
Zero Pitch	8.8	9.2	9.5	9.7
Horizontal distance traveled in feet at:				
Zero Pitch	147.5	123.8	107.2	94.9
Zero Depth	92.9	129.7	-	-

Table 7 - Trajectory Parameters for Sternplane Deflection Rate Variation
Deflection Angle = 15 Degrees

Trajectory Parameters	Sternplane Deflection Rate in degrees/second				
	7.5	15	30	50	75
Elasped time in seconds from launch to:					
Zero Pitch	23.5	23.4	23.2	23.2	23.1
Zero Depth	21.9	22.4	23.4	-	-
Speed in knots at:					
Zero Pitch	24.6	23.7	23.4	23.3	23.3
Zero Depth	34.9	28.2	22.8	-	-
Depth in feet at:					
Zero Pitch	-47.6	-15.5	1.4	8.3	11.8
Pitch in degrees at:					
Zero Depth	38.6	16.3	-2.5	-	-
Upward vertical velocity in feet/sec at:					
Zero Pitch	9.4	9.3	9.2	9.2	9.2
Horizontal distance traveled in feet at:					
Zero Pitch	129.0	124.8	123.8	123.6	123.5
Zero Depth	53.1	86.7	129.7	-	-

seconds after launch, at which time the initial conditions are $V_K = 42.4$ knots and the pitch is 88.4 degrees. A blank space indicates the vehicle did not reach a depth of 4000 feet after being released from 5000 feet.

CONCLUSIONS AND RECOMMENDATIONS

A cruciform configuration of all-movable, rectangular stern appendages having a tip to tip span of 10 feet and chord length of 5 feet provides adequate stability and maneuverability for operational requirements of the 60-foot DOLLY VARDEN.

1. The vehicle exhibits a very weak pitch instability for some ballast conditions in vertical, buoyant rise flight, however, the instability is so weak that the pitch deviation from the vertical is less than 5 degrees for an initial pitch angle of 89 degrees and initial pitch rate of 5 degrees per second.

2. With a net buoyancy of 20,000 pounds, and the center of gravity location 1.5 feet aft of the center of buoyancy, the required speed of 40 knots is attained at the 400-foot depth.

3. Recovery from vertical flight at a depth of 200 feet can be achieved by deflection of the proposed sternplanes to 15 degrees at a rate of 30 degrees/second. This maneuver brings the vehicle to a horizontal attitude near the surface with a forward speed of approximately 23 knots and an upward vertical velocity of 9.2 feet/second.

ACKNOWLEDGMENTS

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APPENDIX A

EQUATIONS FOR DYNAMIC STABILITY

APPENDIX A

EQUATIONS FOR DYNAMIC STABILITY

The equations for the dynamic stability of the DOLLY VARDEN buoyant rise vehicle are derived in this section. Linear equations of motion in the vertical plane are formulated for small perturbations about an arbitrary equilibrium body attitude and speed, and the net buoyancy and longitudinal center of gravity location are retained as arbitrary variables. Because of the geometric symmetry of the DOLLY VARDEN relative to the vertical and horizontal planes, the vertical plane equations are also applicable to the horizontal plane when the net buoyancy is zero and the centers of buoyancy and gravity are coincident.

The formulation, notations, and conventions of this section follow those commonly used in the standard equations for submarine motion as given in Reference 1. The equations of motion are formulated relative to a body fixed Cartesian coordinate system with the origin located at the center of buoyancy. The positive x axis is directed forward along the axis of symmetry, and the positive z axis is directed downward when the vehicle is in a horizontal attitude.

In the equilibrium condition the vehicle is assumed to be moving in a purely forward direction with constant speed U at an angle θ_o relative to the horizontal ($\theta_o = \pi/2$ corresponds to vertical flight.) It should be emphasized that the DOLLY VARDEN buoyant rise vehicle will rapidly accelerate upward initially, thus not strictly satisfying the equilibrium steady speed condition. Therefore, the stability analysis described herein better represents the higher speed than the lower speed flight of the vehicle. The body is perturbed in the pitch mode and the subsequent vertical plane motions (x-z plane) are to be determined. The perturbation velocities in the

x and z directions and the pitch perturbation angular velocity are denoted by u, w, and q, respectively. Due to gravitational effects, displacement dependent terms appear in the equations of motion, and the perturbation pitch displacement is defined by $\theta = \int_0^t q\, dt$.

Under the condition that the center of gravity of the body is located on the body axis of symmetry, the equations for the normal force and pitch moment may be decoupled from the axial motion to first order in the perturbation quantities. The normal force and pitch moment are, respectively.

$$\begin{aligned} m(\dot{w} - Uq - x_G\dot{q}) &= \frac{\rho}{2} L^4 Z'_{\dot{q}}\dot{q} + \frac{\rho}{2} L^3 Z'_{\dot{w}}\dot{w} \\ &+ \frac{\rho}{2} L^3 U Z'_q q + \frac{\rho}{2} L^2 U Z'_w w + \frac{\rho}{2} L^2 U^2 Z'_\theta \theta \end{aligned} \tag{A-1}$$

$$\begin{aligned} I_y\dot{q} - m x_G(\dot{w} - Uq) &= \frac{\rho}{2} L^5 M'_{\dot{q}}\dot{q} + \frac{\rho}{2} L^4 M'_{\dot{w}}\dot{w} \\ &+ \frac{\rho}{2} L^4 U M'_q q + \frac{\rho}{2} L^3 U M'_w w + \frac{\rho}{2} L^3 U^2 M'_\theta \theta \end{aligned} \tag{A-2}$$

where the hydrodynamic coefficients are given in nondimensional form as defined in Reference 1. The metacentric derivatives, Z_θ' and M_θ', are given about the equilibrium pitch angle θ_o as follows:

$$Z'_\theta = \frac{-(W-B)\sin\theta_o}{\frac{\rho}{2} L^2 U^2} \tag{A-3}$$

$$M'_\theta = \frac{(x_G W - x_B B)\sin\theta_o - (z_G W - z_B B)\cos\theta_o}{\frac{\rho}{2} L^3 U^2} \tag{A-4}$$

For this investigation the values of z_G, z_B, and x_B are zero. In addition,

$$q = \frac{d\theta}{dt} \quad , \quad \dot{q} = \frac{d^2\theta}{dt^2} \quad , \quad \dot{w} = \frac{dw}{dt} .$$

Hence, Equations (A-1) and (A-2) form a pair of linear, homogeneous, differential equations for w and θ. The nondimensional roots σ_k' of the characteristic equation for this set

$$A\sigma_k'^3 + B\sigma_k'^2 + C\sigma_k' + D = 0$$

provide the basic form of the solution which is

$$\theta = \sum_{K=1}^{3} \theta_K e^{\sigma_K' t'} \tag{A-5}$$

$$w' = \sum_{K=1}^{3} w_K' e^{\sigma_K' t'}$$

where:

$$A = (Z'_{\dot{w}} - m')(M'_{\dot{q}} - I'_y) - (M'_{\dot{w}} + m'x'_G)(Z'_{\dot{q}} + m'x'_G) \tag{A-6}$$

$$\begin{aligned} B = {} & (Z'_{\dot{w}} - m')(M'_q - m'x'_G) - (M'_{\dot{w}} + m'x'_G)(Z'_q + m') \\ & + Z'_w(M'_{\dot{q}} - I'_y) - M'_w(Z'_{\dot{q}} + m'x'_G) \end{aligned} \tag{A-7}$$

$$\begin{aligned} C = {} & Z'_w(M'_q - m'x'_G) - M'_w(Z'_q + m') \\ & + M'_\theta(Z'_{\dot{w}} - m') - Z'_\theta(M'_{\dot{w}} + m'x'_G) \end{aligned} \tag{A-8}$$

$$D = Z'_w M'_\theta - M'_w Z'_\theta \tag{A-9}$$

and

$$m' = \frac{m}{\frac{\rho}{2} L^3} \quad , \quad I'_y = \frac{I_y}{\frac{\rho}{2} L^5} \quad , \quad x'_G = \frac{x_G}{L}$$

A stable solution for θ and w is obtained when all of the roots of Equation (A-5) have negative real parts. The Routh-Hurwitz criterion, as outlined in Reference 2, provides a simple test for stability. A necessary and sufficient condition for all the roots of Equation (A-5) to have negative real parts is that

$$\left.\begin{array}{l} A,\ B,\ C,\ D > 0 \\ BC - AD > 0 \end{array}\right\} \qquad \text{(A-10)}$$

At infinite speed, the nondimensional metacentric derivatives Z'_θ and M'_θ are zero and the last term, D, in Equation(A-5) is zero. One root of Equation (A-5) is then zero and the other two roots are obtained by the solution of the quadratic,

$$A\sigma'^2 + B\sigma' + C_o = 0 \qquad \text{(A-11)}$$

where A and B are given from Equations (A-6) and (A-7), respectively, and C_o is defined by,

$$C_o = Z'_w(M'_q - m'x'_G) - M'_w(Z'_q + m') \qquad \text{(A-12)}$$

A necessary and sufficient condition that the roots of Equation (A-11) have negative real parts is that

$$A,\ B,\ C_o > 0 \qquad \text{(A-13)}$$

For most body shapes having a reasonable degree of longitudinal symmetry and uniform mass distribution, the coefficients A and B given by Equations (A-6) and (A-7) are positive. The infinite speed stability criterion Equation (A-13) then reduces to $C_o > 0$. A measure of the stability of the system can be given in terms of the stability index G_n, where for stability

$$0 < G_n = 1 - \frac{M'_w (Z'_q + m')}{Z'_w (M'_q - m x'_G)} \qquad \text{(A-14)}$$

and an increasing value of G_n indicates a greater degree of stability.

HORIZONTAL FLIGHT

With the exception that gravitational terms are not present in the horizontal plane, the linearized stability equations for coupled yaw and lateral motion are analogous to the vertical plane equations at infinite speed where in Equations (A-1) and (A-2) v and r, the perturbation velocities in the lateral and yaw modes, replace w and q, respectively, and the horizontal plane derivatives Y' and N' replace the corresponding vertical plane derivatives Z' and M', respectively, as indicated in Table 4.

The DOLLY VARDEN is geometrically symmetric relative to the horizontal and vertical planes, thus the characteristic equation and stability criteria corresponding to infinite speed, vertical plane motion (Equations (A-11) through (A-14)) also provide the stability conditions for the horizontal plane.

APPENDIX B

COMPUTER PRINTOUT OF VERTICAL FLIGHT

20000 POUND BUOYANT RISE

Sternplane Angle = 15 Degrees
Sternplane Rate = 30 Degrees/Sec.
Initial Pitch Angle = 89 Degrees
Initial Speed = 0.0 Knots

Deflection Start Time = 18.9 Sec.
X_G = -1.5 Feet

RUN NUMBER 5

TIME IN SEC	SPEED IN KNOTS	U IN FT/SEC	V IN FT/SEC	W IN FT/SEC	REVS PER MINUTE	STN PLN DEFLECN IN DEG	BOW PLN DEFLECN IN DEG	RUDDER DEFLECN IN DEG	DEPTH IN FEET	PITCH ANGLE IN DEG	ROLL ANGLE IN DEG	HEADING ANGLE IN DEG	WEIGHT CHANGE THOU LB	DISTANCE TRAVELED IN FEET	DEPTH OF BOW IN FEET
0.00	.01	.02	-0.00	-0.00	.02	0.00	0.00	0.00	5000.00	89.00	0.00	0.00	0.00	0.00	4970.50
.20	.34	1.12	0.00	-.01	.02	0.00	0.00	0.00	4999.94	89.00	0.00	0.00	0.00	.00	4970.45
.40	.99	2.22	0.00	-.02	.02	0.00	0.00	0.00	4999.66	89.01	0.00	0.00	0.00	.00	4970.17
.60	1.64	3.33	0.00	-.03	.02	0.00	0.00	0.00	4999.16	89.02	0.00	0.00	0.00	.01	4969.67
.80	2.29	4.43	0.00	-.04	.02	0.00	0.00	0.00	4998.44	89.03	0.00	0.00	0.00	.01	4968.95
1.00	2.95	5.53	0.00	-.04	.02	0.00	0.00	0.00	4997.50	89.04	0.00	0.00	0.00	.02	4968.01
1.20	3.60	6.62	0.00	-.05	.02	0.00	0.00	0.00	4996.34	89.06	0.00	0.00	0.00	.03	4966.85
1.40	4.24	7.72	0.00	-.06	.02	0.00	0.00	0.00	4994.96	89.08	0.00	0.00	0.00	.04	4965.47
1.60	4.89	8.81	0.00	-.07	.02	0.00	0.00	0.00	4993.37	89.11	0.00	0.00	0.00	.06	4963.87
1.80	5.54	9.89	0.00	-.07	.02	0.00	0.00	0.00	4991.55	89.13	0.00	0.00	0.00	.07	4962.05
2.00	6.18	10.98	0.00	-.08	.02	0.00	0.00	0.00	4989.52	89.16	0.00	0.00	0.00	.09	4960.02
2.20	6.82	12.06	0.00	-.08	.02	0.00	0.00	0.00	4987.27	89.18	0.00	0.00	0.00	.10	4957.77
2.40	7.46	13.13	0.00	-.09	.02	0.00	0.00	0.00	4984.80	89.21	0.00	0.00	0.00	.12	4955.30
2.60	8.09	14.20	0.00	-.09	.02	0.00	0.00	0.00	4982.12	89.23	0.00	0.00	0.00	.14	4952.62
2.80	8.73	15.27	0.00	-.09	.02	0.00	0.00	0.00	4979.23	89.26	0.00	0.00	0.00	.16	4949.73
3.00	9.36	16.33	0.00	-.10	.02	0.00	0.00	0.00	4976.12	89.28	0.00	0.00	0.00	.18	4946.62
3.20	9.98	17.39	0.00	-.10	.02	0.00	0.00	0.00	4972.80	89.30	0.00	0.00	0.00	.20	4943.30
3.40	10.60	18.43	0.00	-.10	.02	0.00	0.00	0.00	4969.27	89.31	0.00	0.00	0.00	.23	4939.77
3.60	11.22	19.48	0.00	-.10	.02	0.00	0.00	0.00	4965.53	89.33	0.00	0.00	0.00	.25	4936.03
3.80	11.84	20.51	0.00	-.10	.02	0.00	0.00	0.00	4961.59	89.34	0.00	0.00	0.00	.28	4932.09
4.00	12.45	21.54	0.00	-.10	.02	0.00	0.00	0.00	4957.43	89.35	0.00	0.00	0.00	.30	4927.93
4.20	13.06	22.56	0.00	-.10	.02	0.00	0.00	0.00	4953.07	89.36	0.00	0.00	0.00	.33	4923.57
4.40	13.66	23.58	0.00	-.10	.02	0.00	0.00	0.00	4948.51	89.36	0.00	0.00	0.00	.36	4919.01
4.60	14.26	24.58	0.00	-.10	.02	0.00	0.00	0.00	4943.74	89.36	0.00	0.00	0.00	.40	4914.24
4.80	14.85	25.58	0.00	-.10	.02	0.00	0.00	0.00	4938.78	89.36	0.00	0.00	0.00	.43	4909.28
5.00	15.44	26.57	0.00	-.10	.02	0.00	0.00	0.00	4933.61	89.36	0.00	0.00	0.00	.47	4904.11
5.20	16.03	27.56	0.00	-.10	.02	0.00	0.00	0.00	4928.25	89.36	0.00	0.00	0.00	.51	4898.75
5.40	16.61	28.53	0.00	-.10	.02	0.00	0.00	0.00	4922.69	89.35	0.00	0.00	0.00	.55	4893.19
5.60	17.18	29.50	0.00	-.10	.02	0.00	0.00	0.00	4916.93	89.34	0.00	0.00	0.00	.59	4887.43
5.80	17.75	30.46	0.00	-.10	.02	0.00	0.00	0.00	4910.98	89.34	0.00	0.00	0.00	.64	4881.49
6.00	18.31	31.40	0.00	-.10	.02	0.00	0.00	0.00	4904.84	89.33	0.00	0.00	0.00	.69	4875.35
6.20	18.87	32.34	0.00	-.10	.02	0.00	0.00	0.00	4898.52	89.32	0.00	0.00	0.00	.75	4869.02
6.40	19.43	33.27	0.00	-.10	.02	0.00	0.00	0.00	4892.00	89.30	0.00	0.00	0.00	.80	4862.50
6.60	19.97	34.19	0.00	-.10	.02	0.00	0.00	0.00	4885.30	89.29	0.00	0.00	0.00	.87	4855.80
6.80	20.52	35.11	0.00	-.10	.02	0.00	0.00	0.00	4878.42	89.28	0.00	0.00	0.00	.93	4848.92
7.00	21.05	36.01	0.00	-.10	.02	0.00	0.00	0.00	4871.35	89.27	0.00	0.00	0.00	1.00	4841.85
7.20	21.58	36.90	0.00	-.10	.02	0.00	0.00	0.00	4864.11	89.25	0.00	0.00	0.00	1.07	4834.61
7.40	22.11	37.78	0.00	-.10	.02	0.00	0.00	0.00	4856.68	89.24	0.00	0.00	0.00	1.15	4827.18
7.60	22.63	38.65	0.00	-.10	.02	0.00	0.00	0.00	4849.08	89.23	0.00	0.00	0.00	1.23	4819.58
7.80	23.14	39.51	0.00	-.10	.02	0.00	0.00	0.00	4841.31	89.21	0.00	0.00	0.00	1.32	4811.81
8.00	23.65	40.37	0.00	-.10	.02	0.00	0.00	0.00	4833.36	89.20	0.00	0.00	0.00	1.41	4803.87
8.20	24.15	41.21	0.00	-.10	.02	0.00	0.00	0.00	4825.25	89.18	0.00	0.00	0.00	1.50	4795.75
8.40	24.64	42.04	0.00	-.10	.02	0.00	0.00	0.00	4816.97	89.17	0.00	0.00	0.00	1.60	4787.47
8.60	25.13	42.86	0.00	-.10	.02	0.00	0.00	0.00	4808.52	89.15	0.00	0.00	0.00	1.71	4779.02
8.80	25.62	43.67	0.00	-.10	.02	0.00	0.00	0.00	4799.91	89.14	0.00	0.00	0.00	1.81	4770.41
9.00	26.09	44.47	0.00	-.10	.02	0.00	0.00	0.00	4791.13	89.13	0.00	0.00	0.00	1.93	4761.64
9.20	26.56	45.26	0.00	-.10	.02	0.00	0.00	0.00	4782.20	89.11	0.00	0.00	0.00	2.04	4752.70
9.40	27.03	46.04	0.00	-.10	.02	0.00	0.00	0.00	4773.11	89.10	0.00	0.00	0.00	2.17	4743.61
9.60	27.49	46.81	0.00	-.10	.02	0.00	0.00	0.00	4763.86	89.08	0.00	0.00	0.00	2.29	4734.37
9.80	27.94	47.57	0.00	-.10	.02	0.00	0.00	0.00	4754.46	89.07	0.00	0.00	0.00	2.42	4724.97
10.00	28.38	48.31	0.00	-.10	.02	0.00	0.00	0.00	4744.91	89.05	0.00	0.00	0.00	2.56	4715.42
10.20	28.82	49.05	0.00	-.10	.02	0.00	0.00	0.00	4735.22	89.04	0.00	0.00	0.00	2.70	4705.72
10.40	29.26	49.78	0.00	-.10	.02	0.00	0.00	0.00	4725.37	89.03	0.00	0.00	0.00	2.85	4695.87
10.60	29.69	50.49	0.00	-.10	.02	0.00	0.00	0.00	4715.38	89.01	0.00	0.00	0.00	3.00	4685.88
10.80	30.11	51.20	0.00	-.10	.02	0.00	0.00	0.00	4705.25	89.00	0.00	0.00	0.00	3.16	4675.75

	11.00	30.52	51.90	0.00	-.10	.02	0.00	0.00	0.00	4694.97	88.98	0.00	0.00	0.00	3.32	4665.48
	11.20	30.93	52.58	0.00	-.10	.02	0.00	0.00	0.00	4684.56	88.97	0.00	0.00	0.00	3.48	4655.06
	11.40	31.33	53.26	0.00	-.10	.02	0.00	0.00	0.00	4674.01	88.96	0.00	0.00	0.00	3.65	4644.52
	11.60	31.73	53.92	0.00	-.10	.02	0.00	0.00	0.00	4663.33	88.94	0.00	0.00	0.00	3.83	4633.83
	11.80	32.12	54.57	0.00	-.10	.02	0.00	0.00	0.00	4652.51	88.93	0.00	0.00	0.00	4.01	4623.02
	12.00	32.50	55.22	0.00	-.10	.02	0.00	0.00	0.00	4641.57	88.91	0.00	0.00	0.00	4.20	4612.07
	12.20	32.88	55.85	0.00	-.09	.02	0.00	0.00	0.00	4630.49	88.90	0.00	0.00	0.00	4.39	4601.00
	12.40	33.25	56.47	0.00	-.09	.02	0.00	0.00	0.00	4619.29	88.89	0.00	0.00	0.00	4.59	4589.80
	12.60	33.62	57.09	0.00	-.09	.02	0.00	0.00	0.00	4607.97	88.87	0.00	0.00	0.00	4.79	4578.48
	12.80	33.98	57.69	0.00	-.09	.02	0.00	0.00	0.00	4596.52	88.86	0.00	0.00	0.00	4.99	4567.03
	13.00	34.33	58.28	0.00	-.09	.02	0.00	0.00	0.00	4584.96	88.85	0.00	0.00	0.00	5.21	4555.46
	13.20	34.68	58.87	0.00	-.09	.02	0.00	0.00	0.00	4573.27	88.83	0.00	0.00	0.00	5.42	4543.78
	13.40	35.02	59.44	0.00	-.09	.02	0.00	0.00	0.00	4561.47	88.82	0.00	0.00	0.00	5.65	4531.98
	13.60	35.36	60.01	0.00	-.10	.02	0.00	0.00	0.00	4549.56	88.80	0.00	0.00	0.00	5.87	4520.06
	13.80	35.69	60.56	0.00	-.10	.02	0.00	0.00	0.00	4537.53	88.79	0.00	0.00	0.00	6.11	4508.04
	14.00	36.02	61.11	0.00	-.10	.02	0.00	0.00	0.00	4525.39	88.78	0.00	0.00	0.00	6.34	4495.90
	14.20	36.34	61.64	0.00	-.10	.02	0.00	0.00	0.00	4513.15	88.76	0.00	0.00	0.00	6.59	4483.66
	14.40	36.65	62.17	0.00	-.10	.02	0.00	0.00	0.00	4500.80	88.75	0.00	0.00	0.00	6.84	4471.30
	14.60	36.96	62.68	0.00	-.10	.02	0.00	0.00	0.00	4488.34	88.74	0.00	0.00	0.00	7.09	4458.85
	14.80	37.26	63.19	0.00	-.10	.02	0.00	0.00	0.00	4475.78	88.72	0.00	0.00	0.00	7.35	4446.29
	15.00	37.56	63.69	0.00	-.10	.02	0.00	0.00	0.00	4463.12	88.71	0.00	0.00	0.00	7.61	4433.63
	15.20	37.86	64.18	0.00	-.10	.02	0.00	0.00	0.00	4450.36	88.70	0.00	0.00	0.00	7.88	4420.87
	15.40	38.14	64.66	0.00	-.10	.02	0.00	0.00	0.00	4437.50	88.68	0.00	0.00	0.00	8.15	4408.01
	15.60	38.42	65.13	0.00	-.10	.02	0.00	0.00	0.00	4424.55	88.67	0.00	0.00	0.00	8.43	4395.06
Depth = 400	15.80	38.70	65.60	0.00	-.10	.02	0.00	0.00	0.00	4411.50	88.65	0.00	0.00	0.00	8.72	4382.01
	16.00	38.97	66.05	0.00	-.10	.02	0.00	0.00	0.00	4398.36	88.64	0.00	0.00	0.00	9.01	4368.87
	16.20	39.24	66.50	0.00	-.10	.02	0.00	0.00	0.00	4385.13	88.63	0.00	0.00	0.00	9.30	4355.64
	16.40	39.50	66.94	0.00	-.10	.02	0.00	0.00	0.00	4371.81	88.61	0.00	0.00	0.00	9.60	4342.32
	16.60	39.76	67.37	0.00	-.10	.02	0.00	0.00	0.00	4358.41	88.60	0.00	0.00	0.00	9.91	4328.92
	16.80	40.01	67.79	0.00	-.10	.02	0.00	0.00	0.00	4344.92	88.59	0.00	0.00	0.00	10.22	4315.42
	17.00	40.26	68.20	0.00	-.10	.02	0.00	0.00	0.00	4331.34	88.57	0.00	0.00	0.00	10.54	4301.85
	17.20	40.50	68.61	0.00	-.10	.02	0.00	0.00	0.00	4317.68	88.56	0.00	0.00	0.00	10.86	4288.19
	17.40	40.74	69.01	0.00	-.10	.02	0.00	0.00	0.00	4303.95	88.55	0.00	0.00	0.00	11.19	4274.46
	17.60	40.97	69.40	0.00	-.10	.02	0.00	0.00	0.00	4290.13	88.53	0.00	0.00	0.00	11.52	4260.64
	17.80	41.20	69.78	0.00	-.10	.02	0.00	0.00	0.00	4276.23	88.52	0.00	0.00	0.00	11.85	4246.74
	18.00	41.43	70.16	0.00	-.10	.02	0.00	0.00	0.00	4262.26	88.50	0.00	0.00	0.00	12.20	4232.77
	18.20	41.65	70.52	0.00	-.10	.02	0.00	0.00	0.00	4248.22	88.49	0.00	0.00	0.00	12.54	4218.73
	18.40	41.86	70.89	0.00	-.10	.02	0.00	0.00	0.00	4234.10	88.48	0.00	0.00	0.00	12.90	4204.61
	18.60	42.07	71.24	0.00	-.10	.02	0.00	0.00	0.00	4219.91	88.46	0.00	0.00	0.00	13.26	4190.42
Recovery	18.80	42.28	71.59	0.00	-.10	.02	0.00	0.00	0.00	4205.65	88.45	0.00	0.00	0.00	13.62	4176.16
Initiated	19.00	42.48	71.93	0.00	-.10	.02	3.00	0.00	0.00	4191.32	88.43	0.00	0.00	0.00	13.99	4161.83
18.9 Sec	19.20	42.68	72.18	0.00	-.83	.02	9.00	0.00	0.00	4176.92	88.27	0.00	0.00	0.00	14.34	4147.44
	19.40	42.75	72.06	0.00	-2.55	.02	15.00	0.00	0.00	4162.48	87.02	0.00	0.00	0.00	14.59	4133.02
Depth=200	19.60	42.52	71.26	0.00	-4.90	.02	15.00	0.00	0.00	4148.09	83.97	0.00	0.00	0.00	14.87	4118.76
	19.80	41.98	69.91	0.00	-6.92	.02	15.00	0.00	0.00	4133.88	79.31	0.00	0.00	0.00	15.55	4104.89
	20.00	41.14	68.07	0.00	-8.46	.02	15.00	0.00	0.00	4119.98	73.77	0.00	0.00	0.00	17.01	4091.66
	20.20	40.03	65.88	0.00	-9.54	.02	15.00	0.00	0.00	4106.59	67.83	0.00	0.00	0.00	19.45	4079.27
	20.40	38.76	63.51	0.00	-10.23	.02	15.00	0.00	0.00	4093.85	61.79	0.00	0.00	0.00	22.90	4067.85
	20.60	37.41	61.10	0.00	-10.63	.02	15.00	0.00	0.00	4081.90	55.86	0.00	0.00	0.00	27.34	4057.48
	20.80	36.04	58.75	0.00	-10.81	.02	15.00	0.00	0.00	4070.81	50.13	0.00	0.00	0.00	32.64	4048.17
	21.00	34.70	56.48	0.00	-10.86	.02	15.00	0.00	0.00	4060.64	44.65	0.00	0.00	0.00	38.68	4039.91
	21.20	33.42	54.33	0.00	-10.81	.02	15.00	0.00	0.00	4051.38	39.44	0.00	0.00	0.00	45.32	4032.65
	21.40	32.19	52.30	0.00	-10.71	.02	15.00	0.00	0.00	4043.03	34.49	0.00	0.00	0.00	52.45	4026.33
	21.60	31.03	50.37	0.00	-10.58	.02	15.00	0.00	0.00	4035.56	29.81	0.00	0.00	0.00	59.93	4020.89
	21.80	29.93	48.55	0.00	-10.42	.02	15.00	0.00	0.00	4028.92	25.38	0.00	0.00	0.00	67.67	4016.20
	22.00	28.88	46.82	0.00	-10.26	.02	15.00	0.00	0.00	4023.07	21.18	0.00	0.00	0.00	75.58	4012.41
	22.20	27.89	45.17	0.00	-10.09	.02	15.00	0.00	0.00	4017.95	17.20	0.00	0.00	0.00	83.59	4009.22
	22.40	26.93	43.60	0.00	-9.92	.02	15.00	0.00	0.00	4013.51	13.44	0.00	0.00	0.00	91.62	4006.66
	22.60	26.02	42.09	0.00	-9.75	.02	15.00	0.00	0.00	4009.71	9.87	0.00	0.00	0.00	99.63	4004.65
Depth=0	22.80	25.15	40.65	0.00	-9.58	.02	15.00	0.00	0.00	4006.48	6.49	0.00	0.00	0.00	107.57	4003.15
	23.00	24.31	39.25	0.00	-9.41	.02	15.00	0.00	0.00	4003.79	3.30	0.00	0.00	0.00	115.46	4002.09
Pitch=0	23.20	23.50	37.90	0.00	-9.25	.02	15.00	0.00	0.00	4001.57	.27	0.00	0.00	0.00	123.09	4001.43
	23.40	22.71	36.60	0.00	-9.09	.02	15.00	0.00	0.00	3999.79	-2.59	0.00	0.00	0.00	130.62	4001.12
	23.60	21.95	35.34	0.00	-8.94	.02	15.00	0.00	0.00	3998.39	-5.29	0.00	0.00	0.00	137.97	4001.11
	23.80	21.22	34.12	0.00	-8.79	.02	15.00	0.00	0.00	3997.34	-7.84	0.00	0.00	0.00	145.12	4001.37
	24.00	20.51	32.93	0.00	-8.64	.02	15.00	0.00	0.00	3996.60	-10.24	0.00	0.00	0.00	152.07	4001.85

24.20	19.82	31.78	0.00	-8.50	.02	15.00	0.00	0.00	3996.14	-12.50	0.00	0.00	0.00	158.00	4002.52
[illegible]	19.15	30.67	0.00	-8.36	.02	15.00	0.00	0.00	3995.91	-14.62	0.00	0.00	0.00	165.32	4003.36
24.60	18.50	29.58	0.00	-8.23	.02	15.00	0.00	0.00	3995.89	-16.61	0.00	0.00	0.00	171.62	4004.32
24.80	17.86	28.52	0.00	-8.10	.02	15.00	0.00	0.00	3996.04	-18.47	0.00	0.00	0.00	177.71	4005.39
25.00	17.25	27.49	0.00	-7.97	.02	15.00	0.00	0.00	3996.35	-20.20	0.00	0.00	0.00	183.58	4006.53
25.20	16.65	26.50	0.00	-7.85	.02	15.00	0.00	0.00	3996.78	-21.81	0.00	0.00	0.00	189.24	4007.74
25.40	16.07	25.53	0.00	-7.73	.02	15.00	0.00	0.00	3997.31	-23.29	0.00	0.00	0.00	194.69	4008.98
25.60	15.51	24.58	0.00	-7.62	.02	15.00	0.00	0.00	3997.93	-24.66	0.00	0.00	0.00	199.94	4010.24
25.80	14.97	23.67	0.00	-7.51	.02	15.00	0.00	0.00	3998.61	-25.91	0.00	0.00	0.00	205.00	4011.50
26.00	14.44	22.78	0.00	-7.41	.02	15.00	0.00	0.00	3999.34	-27.04	0.00	0.00	0.00	209.86	4012.75
26.20	13.93	21.92	0.00	-7.31	.02	15.00	0.00	0.00	4000.09	-28.06	0.00	0.00	0.00	214.55	4013.97
26.40	13.43	21.08	0.00	-7.21	.02	15.00	0.00	0.00	4000.87	-28.97	0.00	0.00	0.00	219.06	4015.16
26.60	12.96	20.28	0.00	-7.13	.02	15.00	0.00	0.00	4001.65	-29.76	0.00	0.00	0.00	223.41	4016.29
26.80	12.50	19.50	0.00	-7.04	.02	15.00	0.00	0.00	4002.42	-30.45	0.00	0.00	0.00	227.60	4017.37
27.00	12.05	18.74	0.00	-6.97	.02	15.00	0.00	0.00	4003.18	-31.03	0.00	0.00	0.00	231.64	4018.39
27.20	11.63	18.02	0.00	-6.90	.02	15.00	0.00	0.00	4003.91	-31.50	0.00	0.00	0.00	235.54	4019.32
27.40	11.22	17.32	0.00	-6.83	.02	15.00	0.00	0.00	4004.61	-31.86	0.00	0.00	0.00	239.30	4020.18
27.60	10.83	16.65	0.00	-6.77	.02	15.00	0.00	0.00	4005.26	-32.12	0.00	0.00	0.00	242.93	4020.95
27.80	10.46	16.01	0.00	-6.72	.02	15.00	0.00	0.00	4005.88	-32.26	0.00	0.00	0.00	246.44	4021.62
28.00	10.11	15.40	0.00	-6.67	.02	15.00	0.00	0.00	4006.44	-32.31	0.00	0.00	0.00	249.84	4022.20
28.20	9.78	14.83	0.00	-6.63	.02	15.00	0.00	0.00	4006.94	-32.24	0.00	0.00	0.00	253.13	4022.68
28.40	9.46	14.28	0.00	-6.58	.02	15.00	0.00	0.00	4007.38	-32.07	0.00	0.00	0.00	256.32	4023.05
28.60	9.17	13.77	0.00	-6.54	.02	15.00	0.00	0.00	4007.77	-31.79	0.00	0.00	0.00	259.42	4023.31
28.80	8.89	13.29	0.00	-6.50	.02	15.00	0.00	0.00	4008.09	-31.41	0.00	0.00	0.00	262.43	4023.47
29.00	8.63	12.84	0.00	-6.45	.02	15.00	0.00	0.00	4008.35	-30.93	0.00	0.00	0.00	265.35	4023.52
29.20	8.39	12.43	0.00	-6.41	.02	15.00	0.00	0.00	4008.55	-30.34	0.00	0.00	0.00	268.20	4023.45
29.40	8.18	12.05	0.00	-6.38	.02	15.00	0.00	0.00	4008.68	-29.65	0.00	0.00	0.00	270.98	4023.28
29.60	7.98	11.72	0.00	-6.34	.02	15.00	0.00	0.00	4008.75	-28.87	0.00	0.00	0.00	273.69	4022.99
29.80	7.80	11.41	0.00	-6.31	.02	15.00	0.00	0.00	4008.76	-27.98	0.00	0.00	0.00	276.34	4022.60
30.00	7.65	11.15	0.00	-6.29	.02	15.00	0.00	0.00	4008.70	-27.00	0.00	0.00	0.00	278.93	4022.09
30.20	7.51	10.92	0.00	-6.26	.02	15.00	0.00	0.00	4008.57	-25.93	0.00	0.00	0.00	281.48	4021.47
30.40	7.40	10.73	0.00	-6.24	.02	15.00	0.00	0.00	4008.38	-24.77	0.00	0.00	0.00	283.98	4020.74
30.60	7.31	10.59	0.00	-6.23	.02	15.00	0.00	0.00	4008.13	-23.52	0.00	0.00	0.00	286.44	4019.91
30.80	7.24	10.48	0.00	-6.21	.02	15.00	0.00	0.00	4007.82	-22.19	0.00	0.00	0.00	288.87	4018.96
31.00	7.19	10.42	0.00	-6.20	.02	15.00	0.00	0.00	4007.45	-20.78	0.00	0.00	0.00	291.28	4017.92
31.20	7.17	10.40	0.00	-6.19	.02	15.00	0.00	0.00	4007.01	-19.30	0.00	0.00	0.00	293.66	4016.76
31.40	7.16	10.42	0.00	-6.18	.02	15.00	0.00	0.00	4006.52	-17.74	0.00	0.00	0.00	296.03	4015.51
31.60	7.18	10.48	0.00	-6.17	.02	15.00	0.00	0.00	4005.96	-16.13	0.00	0.00	0.00	298.39	4014.16
31.80	7.22	10.58	0.00	-6.16	.02	15.00	0.00	0.00	4005.34	-14.46	0.00	0.00	0.00	300.74	4012.71
32.00	7.28	10.72	0.00	-6.16	.02	15.00	0.00	0.00	4004.66	-12.74	0.00	0.00	0.00	303.10	4011.17
32.20	7.36	10.90	0.00	-6.15	.02	15.00	0.00	0.00	4003.92	-10.99	0.00	0.00	0.00	305.47	4009.54
32.40	7.47	11.12	0.00	-6.15	.02	15.00	0.00	0.00	4003.11	-9.28	0.00	0.00	0.00	307.85	4007.83
32.60	7.59	11.38	0.00	-6.14	.02	15.00	0.00	0.00	4002.24	-7.39	0.00	0.00	0.00	310.24	4006.03
32.80	7.73	11.67	0.00	-6.13	.02	15.00	0.00	0.00	4001.29	-5.58	0.00	0.00	0.00	312.67	4004.16
33.00	7.89	11.99	0.00	-6.13	.02	15.00	0.00	0.00	4000.28	-3.76	0.00	0.00	0.00	315.12	4002.22
33.20	8.07	12.35	0.00	-6.12	.02	15.00	0.00	0.00	3999.20	-1.95	0.00	0.00	0.00	317.60	4000.20
33.40	8.26	12.73	0.00	-6.12	.02	15.00	0.00	0.00	3998.04	-.17	0.00	0.00	0.00	320.12	3998.13
33.60	8.47	13.13	0.00	-6.11	.02	15.00	0.00	0.00	3996.80	1.59	0.00	0.00	0.00	322.68	3995.99
33.80	8.69	13.55	0.00	-6.11	.02	15.00	0.00	0.00	3995.49	3.30	0.00	0.00	0.00	325.28	3993.79
34.00	8.92	13.99	0.00	-6.11	.02	15.00	0.00	0.00	3994.09	4.95	0.00	0.00	0.00	327.93	3991.54
34.20	9.16	14.45	0.00	-6.11	.02	15.00	0.00	0.00	3992.61	6.55	0.00	0.00	0.00	330.62	3989.25
34.40	9.41	14.91	0.00	-6.11	.02	15.00	0.00	0.00	3991.05	8.07	0.00	0.00	0.00	333.37	3986.90
34.60	9.67	15.38	0.00	-6.11	.02	15.00	0.00	0.00	3989.40	9.52	0.00	0.00	0.00	336.16	3984.52
34.80	9.93	15.86	0.00	-6.11	.02	15.00	0.00	0.00	3987.66	10.88	0.00	0.00	0.00	339.00	3982.10
35.00	10.20	16.34	0.00	-6.12	.02	15.00	0.00	0.00	3985.84	12.15	0.00	0.00	0.00	341.90	3979.63
35.20	10.46	16.81	0.00	-6.13	.02	15.00	0.00	0.00	3983.94	13.32	0.00	0.00	0.00	344.85	3977.14
35.40	10.73	17.28	0.00	-6.15	.02	15.00	0.00	0.00	3981.95	14.39	0.00	0.00	0.00	347.85	3974.62
35.60	10.99	17.74	0.00	-6.16	.02	15.00	0.00	0.00	3979.88	15.36	0.00	0.00	0.00	350.91	3972.07
35.80	11.25	18.19	0.00	-6.18	.02	15.00	0.00	0.00	3977.73	16.22	0.00	0.00	0.00	354.02	3969.49
36.00	11.50	18.63	0.00	-6.21	.02	15.00	0.00	0.00	3975.51	16.98	0.00	0.00	0.00	357.18	3966.90

20000 POUND BUOYANT RISE (NO RECOVERY)

Initial Pitch Angle = 89 degrees
Initial Pitch Rate = -0.25 degrees/second

RUN NUMBER 1

x_G = -1.5 feet

TIME IN SEC	SPEED IN KNOTS	U IN FT/SEC	V IN FT/SEC	W IN FT/SEC	REVS PER MINUTE	STN PLN DEFLECN IN DEG	BOW PLN DEFLECN IN DEG	RUDDER DEFLECN IN DEG	DEPTH IN FEET	PITCH ANGLE IN DEG	ROLL ANGLE IN DEG	HEADING ANGLE IN DEG	WEIGHT CHANGE THOU LB	DISTANCE TRAVELED IN FEET	DEPTH OF BOW IN FEET
0.00	.01	.02	-0.00	-0.00	.02	0.00	0.00	0.00	5000.00	89.00	0.00	0.00	0.00	0.00	4970.50
.20	.34	1.12	0.00	-.01	.02	0.00	0.00	0.00	4999.94	88.95	0.00	0.00	0.00	.00	4970.45
.40	.99	2.22	0.00	-.02	.02	0.00	0.00	0.00	4999.66	88.91	0.00	0.00	0.00	.00	4970.17
.60	1.64	3.33	0.00	-.03	.02	0.00	0.00	0.00	4999.16	88.87	0.00	0.00	0.00	.01	4969.67
.80	2.29	4.43	0.00	-.04	.02	0.00	0.00	0.00	4998.44	88.83	0.00	0.00	0.00	.02	4968.95
1.00	2.95	5.52	0.00	-.05	.02	0.00	0.00	0.00	4997.50	88.80	0.00	0.00	0.00	.03	4968.01
1.20	3.60	6.62	0.00	-.06	.02	0.00	0.00	0.00	4996.34	88.78	0.00	0.00	0.00	.04	4966.85
1.40	4.24	7.72	0.00	-.07	.02	0.00	0.00	0.00	4994.96	88.76	0.00	0.00	0.00	.06	4965.47
1.60	4.89	8.81	0.00	-.08	.02	0.00	0.00	0.00	4993.37	88.75	0.00	0.00	0.00	.08	4963.87
1.80	5.54	9.89	0.00	-.09	.02	0.00	0.00	0.00	4991.55	88.74	0.00	0.00	0.00	.10	4962.06
2.00	6.18	10.98	0.00	-.10	.02	0.00	0.00	0.00	4989.52	88.73	0.00	0.00	0.00	.13	4960.02
2.20	6.82	12.06	0.00	-.11	.02	0.00	0.00	0.00	4987.27	88.73	0.00	0.00	0.00	.15	4957.78
2.40	7.46	13.13	0.00	-.12	.02	0.00	0.00	0.00	4984.80	88.73	0.00	0.00	0.00	.19	4955.31
2.60	8.09	14.20	0.00	-.13	.02	0.00	0.00	0.00	4982.12	88.73	0.00	0.00	0.00	.22	4952.63
2.80	8.72	15.27	0.00	-.14	.02	0.00	0.00	0.00	4979.23	88.74	0.00	0.00	0.00	.26	4949.74
3.00	9.35	16.33	0.00	-.14	.02	0.00	0.00	0.00	4976.12	88.75	0.00	0.00	0.00	.30	4946.63
3.20	9.98	17.38	0.00	-.15	.02	0.00	0.00	0.00	4972.80	88.75	0.00	0.00	0.00	.34	4943.31
3.40	10.60	18.43	0.00	-.15	.02	0.00	0.00	0.00	4969.28	88.76	0.00	0.00	0.00	.39	4939.78
3.60	11.22	19.47	0.00	-.16	.02	0.00	0.00	0.00	4965.54	88.77	0.00	0.00	0.00	.44	4936.04
3.80	11.84	20.51	0.00	-.16	.02	0.00	0.00	0.00	4961.59	88.77	0.00	0.00	0.00	.49	4932.10
4.00	12.45	21.54	0.00	-.16	.02	0.00	0.00	0.00	4957.44	88.78	0.00	0.00	0.00	.55	4927.95
4.20	13.05	22.56	0.00	-.17	.02	0.00	0.00	0.00	4953.08	88.78	0.00	0.00	0.00	.61	4923.59
4.40	13.66	23.57	0.00	-.17	.02	0.00	0.00	0.00	4948.52	88.78	0.00	0.00	0.00	.67	4919.02
4.60	14.26	24.58	0.00	-.17	.02	0.00	0.00	0.00	4943.75	88.78	0.00	0.00	0.00	.74	4914.26
4.80	14.85	25.58	0.00	-.17	.02	0.00	0.00	0.00	4938.79	88.77	0.00	0.00	0.00	.81	4909.29
5.00	15.44	26.57	0.00	-.17	.02	0.00	0.00	0.00	4933.62	88.77	0.00	0.00	0.00	.89	4904.13
5.20	16.02	27.55	0.00	-.17	.02	0.00	0.00	0.00	4928.26	88.76	0.00	0.00	0.00	.97	4898.77
5.40	16.60	28.53	0.00	-.18	.02	0.00	0.00	0.00	4922.70	88.75	0.00	0.00	0.00	1.06	4893.21
5.60	17.18	29.49	0.00	-.18	.02	0.00	0.00	0.00	4916.95	88.74	0.00	0.00	0.00	1.15	4887.45
5.80	17.75	30.45	0.00	-.18	.02	0.00	0.00	0.00	4911.00	88.72	0.00	0.00	0.00	1.24	4881.51
6.00	18.31	31.40	0.00	-.18	.02	0.00	0.00	0.00	4904.86	88.71	0.00	0.00	0.00	1.35	4875.37
6.20	18.87	32.34	0.00	-.18	.02	0.00	0.00	0.00	4898.54	88.69	0.00	0.00	0.00	1.45	4869.05
6.40	19.42	33.27	0.00	-.18	.02	0.00	0.00	0.00	4892.02	88.67	0.00	0.00	0.00	1.57	4862.53
6.60	19.97	34.19	0.00	-.18	.02	0.00	0.00	0.00	4885.33	88.66	0.00	0.00	0.00	1.69	4855.83
6.80	20.51	35.10	0.00	-.18	.02	0.00	0.00	0.00	4878.44	88.64	0.00	0.00	0.00	1.81	4848.95
7.00	21.05	36.00	0.00	-.18	.02	0.00	0.00	0.00	4871.38	88.62	0.00	0.00	0.00	1.95	4841.89
7.20	21.58	36.89	0.00	-.18	.02	0.00	0.00	0.00	4864.14	88.59	0.00	0.00	0.00	2.09	4834.64
7.40	22.10	37.77	0.00	-.18	.02	0.00	0.00	0.00	4856.71	88.57	0.00	0.00	0.00	2.24	4827.22
7.60	22.62	38.65	0.00	-.18	.02	0.00	0.00	0.00	4849.12	88.55	0.00	0.00	0.00	2.39	4819.63
7.80	23.14	39.51	0.00	-.18	.02	0.00	0.00	0.00	4841.35	88.53	0.00	0.00	0.00	2.55	4811.86
8.00	23.64	40.36	0.00	-.18	.02	0.00	0.00	0.00	4833.40	88.50	0.00	0.00	0.00	2.72	4803.91
8.20	24.15	41.20	0.00	-.18	.02	0.00	0.00	0.00	4825.29	88.48	0.00	0.00	0.00	2.90	4795.80
8.40	24.64	42.03	0.00	-.18	.02	0.00	0.00	0.00	4817.01	88.45	0.00	0.00	0.00	3.09	4787.52
8.60	25.13	42.85	0.00	-.18	.02	0.00	0.00	0.00	4808.57	88.43	0.00	0.00	0.00	3.28	4779.08
8.80	25.61	43.66	0.00	-.18	.02	0.00	0.00	0.00	4799.96	88.41	0.00	0.00	0.00	3.48	4770.47
9.00	26.09	44.46	0.00	-.18	.02	0.00	0.00	0.00	4791.19	88.38	0.00	0.00	0.00	3.69	4761.70
9.20	26.56	45.25	0.00	-.17	.02	0.00	0.00	0.00	4782.26	88.36	0.00	0.00	0.00	3.91	4752.77
9.40	27.02	46.03	0.00	-.17	.02	0.00	0.00	0.00	4773.17	88.33	0.00	0.00	0.00	4.14	4743.68
9.60	27.48	46.80	0.00	-.17	.02	0.00	0.00	0.00	4763.93	88.31	0.00	0.00	0.00	4.37	4734.44
9.80	27.93	47.56	0.00	-.17	.02	0.00	0.00	0.00	4754.53	88.28	0.00	0.00	0.00	4.61	4725.05
10.00	28.38	48.30	0.00	-.17	.02	0.00	0.00	0.00	4744.99	88.26	0.00	0.00	0.00	4.87	4715.50
10.20	28.82	49.04	0.00	-.17	.02	0.00	0.00	0.00	4735.29	88.23	0.00	0.00	0.00	5.13	4705.81
10.40	29.25	49.77	0.00	-.17	.02	0.00	0.00	0.00	4725.45	88.21	0.00	0.00	0.00	5.40	4695.97
10.60	29.68	50.48	0.00	-.17	.02	0.00	0.00	0.00	4715.47	88.18	0.00	0.00	0.00	5.68	4685.98
10.80	30.10	51.19	0.00	-.17	.02	0.00	0.00	0.00	4705.34	88.16	0.00	0.00	0.00	5.96	4675.85
11.00	30.51	51.88	0.00	-.17	.02	0.00	0.00	0.00	4695.07	88.13	0.00	0.00	0.00	6.26	4665.59
11.20	30.92	52.57	0.00	-.17	.02	0.00	0.00	0.00	4684.66	88.11	0.00	0.00	0.00	6.57	4655.18

11.40	31.33	53.24	0.00	-.17	.02	0.00	0.00	0.00	4674.12	88.08	0.00	0.00	0.00	6.88	4644.64
11.60	31.72	53.91	0.00	-.17	.02	0.00	0.00	0.00	4663.44	88.06	0.00	0.00	0.00	7.20	4633.96
11.80	32.11	54.56	0.00	-.17	.02	0.00	0.00	0.00	4652.63	88.04	0.00	0.00	0.00	7.54	4623.15
12.00	32.50	55.20	0.00	-.17	.02	0.00	0.00	0.00	4641.69	88.01	0.00	0.00	0.00	7.88	4612.21
12.20	32.87	55.84	0.00	-.17	.02	0.00	0.00	0.00	4630.63	87.99	0.00	0.00	0.00	8.23	4601.15
12.40	33.25	56.46	0.00	-.17	.02	0.00	0.00	0.00	4619.43	87.96	0.00	0.00	0.00	8.59	4589.95
12.60	33.61	57.07	0.00	-.17	.02	0.00	0.00	0.00	4608.12	87.94	0.00	0.00	0.00	8.96	4578.64
12.80	33.97	57.68	0.00	-.17	.02	0.00	0.00	0.00	4596.68	87.91	0.00	0.00	0.00	9.34	4567.20
13.00	34.33	58.27	0.00	-.17	.02	0.00	0.00	0.00	4585.12	87.89	0.00	0.00	0.00	9.73	4555.64
13.20	34.67	58.85	0.00	-.17	.02	0.00	0.00	0.00	4573.44	87.86	0.00	0.00	0.00	10.12	4543.96
13.40	35.02	59.43	0.00	-.17	.02	0.00	0.00	0.00	4561.65	87.84	0.00	0.00	0.00	10.53	4532.17
13.60	35.35	59.99	0.00	-.17	.02	0.00	0.00	0.00	4549.74	87.82	0.00	0.00	0.00	10.95	4520.27
13.80	35.68	60.54	0.00	-.17	.02	0.00	0.00	0.00	4537.73	87.79	0.00	0.00	0.00	11.37	4508.25
14.00	36.01	61.09	0.00	-.17	.02	0.00	0.00	0.00	4525.60	87.77	0.00	0.00	0.00	11.81	4496.12
14.20	36.33	61.62	0.00	-.17	.02	0.00	0.00	0.00	4513.36	87.74	0.00	0.00	0.00	12.25	4483.88
14.40	36.64	62.15	0.00	-.17	.02	0.00	0.00	0.00	4501.02	87.72	0.00	0.00	0.00	12.70	4471.54
14.60	36.95	62.67	0.00	-.17	.02	0.00	0.00	0.00	4488.57	87.69	0.00	0.00	0.00	13.17	4459.09
14.80	37.25	63.17	0.00	-.17	.02	0.00	0.00	0.00	4476.02	87.67	0.00	0.00	0.00	13.64	4446.54
15.00	37.55	63.67	0.00	-.17	.02	0.00	0.00	0.00	4463.37	87.65	0.00	0.00	0.00	14.12	4433.89
15.20	37.84	64.16	0.00	-.17	.02	0.00	0.00	0.00	4450.62	87.62	0.00	0.00	0.00	14.61	4421.14
15.40	38.13	64.64	0.00	-.17	.02	0.00	0.00	0.00	4437.77	87.60	0.00	0.00	0.00	15.11	4408.30
15.60	38.41	65.11	0.00	-.17	.02	0.00	0.00	0.00	4424.83	87.57	0.00	0.00	0.00	15.62	4395.36
15.80	38.69	65.58	0.00	-.17	.02	0.00	0.00	0.00	4411.79	87.55	0.00	0.00	0.00	16.14	4382.32
16.00	38.96	66.03	0.00	-.18	.02	0.00	0.00	0.00	4398.67	87.52	0.00	0.00	0.00	16.67	4369.19
16.20	39.23	66.48	0.00	-.18	.02	0.00	0.00	0.00	4385.45	87.50	0.00	0.00	0.00	17.20	4355.98
16.40	39.49	66.92	0.00	-.18	.02	0.00	0.00	0.00	4372.14	87.48	0.00	0.00	0.00	17.75	4342.67
16.60	39.75	67.35	0.00	-.18	.02	0.00	0.00	0.00	4358.75	87.45	0.00	0.00	0.00	18.31	4329.28
16.80	40.00	67.77	0.00	-.18	.02	0.00	0.00	0.00	4345.27	87.43	0.00	0.00	0.00	18.87	4315.80
17.00	40.25	68.18	0.00	-.18	.02	0.00	0.00	0.00	4331.71	87.40	0.00	0.00	0.00	19.45	4302.24
17.20	40.49	68.59	0.00	-.18	.02	0.00	0.00	0.00	4318.06	87.38	0.00	0.00	0.00	20.03	4288.59
17.40	40.73	68.98	0.00	-.18	.02	0.00	0.00	0.00	4304.34	87.35	0.00	0.00	0.00	20.63	4274.87
17.60	40.96	69.37	0.00	-.18	.02	0.00	0.00	0.00	4290.54	87.33	0.00	0.00	0.00	21.23	4261.07
17.80	41.19	69.76	0.00	-.18	.02	0.00	0.00	0.00	4276.65	87.30	0.00	0.00	0.00	21.85	4247.19
18.00	41.41	70.13	0.00	-.18	.02	0.00	0.00	0.00	4262.70	87.28	0.00	0.00	0.00	22.47	4233.23
18.20	41.63	70.50	0.00	-.18	.02	0.00	0.00	0.00	4248.67	87.25	0.00	0.00	0.00	23.10	4219.20
18.40	41.85	70.86	0.00	-.18	.02	0.00	0.00	0.00	4234.56	87.23	0.00	0.00	0.00	23.74	4205.10
18.60	42.06	71.21	0.00	-.18	.02	0.00	0.00	0.00	4220.39	87.20	0.00	0.00	0.00	24.39	4190.92
18.80	42.27	71.56	0.00	-.18	.02	0.00	0.00	0.00	4206.14	87.18	0.00	0.00	0.00	25.06	4176.68
19.00	42.47	71.90	0.00	-.18	.02	0.00	0.00	0.00	4191.83	87.15	0.00	0.00	0.00	25.73	4162.37
19.20	42.67	72.23	0.00	-.18	.02	0.00	0.00	0.00	4177.45	87.13	0.00	0.00	0.00	26.41	4147.99
19.40	42.86	72.56	0.00	-.18	.02	0.00	0.00	0.00	4163.01	87.10	0.00	0.00	0.00	27.09	4133.54
19.60	43.05	72.88	0.00	-.18	.02	0.00	0.00	0.00	4148.49	87.08	0.00	0.00	0.00	27.79	4119.03
19.80	43.24	73.19	0.00	-.19	.02	0.00	0.00	0.00	4133.92	87.05	0.00	0.00	0.00	28.50	4104.46
20.00	43.42	73.50	0.00	-.19	.02	0.00	0.00	0.00	4119.28	87.03	0.00	0.00	0.00	29.22	4089.82
20.20	43.60	73.80	0.00	-.19	.02	0.00	0.00	0.00	4104.59	87.00	0.00	0.00	0.00	29.95	4075.13
20.40	43.78	74.09	0.00	-.19	.02	0.00	0.00	0.00	4089.83	86.98	0.00	0.00	0.00	30.68	4060.37
20.60	43.95	74.38	0.00	-.19	.02	0.00	0.00	0.00	4075.02	86.95	0.00	0.00	0.00	31.43	4045.56
20.80	44.12	74.66	0.00	-.19	.02	0.00	0.00	0.00	4060.15	86.93	0.00	0.00	0.00	32.19	4030.69
21.00	44.29	74.94	0.00	-.19	.02	0.00	0.00	0.00	4045.22	86.90	0.00	0.00	0.00	32.95	4015.77
21.20	44.45	75.21	0.00	-.19	.02	0.00	0.00	0.00	4030.24	86.87	0.00	0.00	0.00	33.73	4000.79
21.40	44.61	75.47	0.00	-.19	.02	0.00	0.00	0.00	4015.21	86.85	0.00	0.00	0.00	34.51	3985.75
21.60	44.76	75.73	0.00	-.19	.02	0.00	0.00	0.00	4000.12	86.82	0.00	0.00	0.00	35.30	3970.67
21.80	44.91	75.98	0.00	-.19	.02	0.00	0.00	0.00	3984.99	86.79	0.00	0.00	0.00	36.11	3955.53
22.00	45.06	76.23	0.00	-.19	.02	0.00	0.00	0.00	3969.80	86.77	0.00	0.00	0.00	36.92	3940.34
22.20	45.21	76.47	0.00	-.20	.02	0.00	0.00	0.00	3954.56	86.74	0.00	0.00	0.00	37.74	3925.11
22.40	45.35	76.71	0.00	-.20	.02	0.00	0.00	0.00	3939.28	86.72	0.00	0.00	0.00	38.58	3909.83
22.60	45.49	76.94	0.00	-.20	.02	0.00	0.00	0.00	3923.95	86.69	0.00	0.00	0.00	39.42	3894.50
22.80	45.62	77.17	0.00	-.20	.02	0.00	0.00	0.00	3908.57	86.66	0.00	0.00	0.00	40.27	3879.12
23.00	45.76	77.40	0.00	-.20	.02	0.00	0.00	0.00	3893.15	86.63	0.00	0.00	0.00	41.13	3863.70
23.20	45.89	77.61	0.00	-.20	.02	0.00	0.00	0.00	3877.68	86.61	0.00	0.00	0.00	42.00	3848.23
23.40	46.02	77.83	0.00	-.20	.02	0.00	0.00	0.00	3862.17	86.58	0.00	0.00	0.00	42.89	3832.73
23.60	46.14	78.04	0.00	-.20	.02	0.00	0.00	0.00	3846.62	86.55	0.00	0.00	0.00	43.78	3817.18
23.80	46.26	78.24	0.00	-.20	.02	0.00	0.00	0.00	3831.03	86.53	0.00	0.00	0.00	44.68	3801.59
24.00	46.38	78.44	0.00	-.20	.02	0.00	0.00	0.00	3815.40	86.50	0.00	0.00	0.00	45.59	3785.96
24.20	46.50	78.64	0.00	-.21	.02	0.00	0.00	0.00	3799.73	86.47	0.00	0.00	0.00	46.51	3770.29
24.40	46.61	78.83	0.00	-.21	.02	0.00	0.00	0.00	3784.02	86.44	0.00	0.00	0.00	47.44	3754.58

20000 POUND BUOYANT RISE (NO RECOVERY)

SECOND PAGE OF OUTPUT FOR RUN 1 x_G = -1.5 feet

Initial Pitch Angle = 89 degrees
Initial Pitch Rate = -0.25 degrees/second

TIME IN SEC	P IN DEG/SEC	Q IN DEG/SEC	R IN DEG/SEC	ALFA IN DEGREES	BETA IN DEGREES	X IN FEET	Y IN FEET	DEPTH RATE IN FT/SEC
0.00	0.00	-.25	0.00	0.00	0.00	0.00	0.00	0.00
.20	0.00	-.23	0.00	-.48	0.00	.00	0.00	-.57
.40	0.00	-.21	0.00	-.50	0.00	.00	0.00	-1.67
.60	0.00	-.18	0.00	-.51	0.00	.01	0.00	-2.77
.80	0.00	-.15	0.00	-.52	0.00	.02	0.00	-3.88
1.00	0.00	-.13	0.00	-.53	0.00	.03	0.00	-4.98
1.20	0.00	-.10	0.00	-.54	0.00	.04	0.00	-6.07
1.40	0.00	-.08	0.00	-.54	0.00	.06	0.00	-7.17
1.60	0.00	-.05	0.00	-.54	0.00	.08	0.00	-8.26
1.80	0.00	-.03	0.00	-.54	0.00	.10	0.00	-9.35
2.00	0.00	-.01	0.00	-.54	0.00	.13	0.00	-10.44
2.20	0.00	.00	0.00	-.53	0.00	.15	0.00	-11.52
2.40	0.00	.02	0.00	-.52	0.00	.19	0.00	-12.59
2.60	0.00	.03	0.00	-.52	0.00	.22	0.00	-13.67
2.80	0.00	.03	0.00	-.51	0.00	.26	0.00	-14.74
3.00	0.00	.03	0.00	-.50	0.00	.30	0.00	-15.80
3.20	0.00	.03	0.00	-.49	0.00	.34	0.00	-16.86
3.40	0.00	.03	0.00	-.47	0.00	.39	0.00	-17.91
3.60	0.00	.03	0.00	-.46	0.00	.44	0.00	-18.95
3.80	0.00	.02	0.00	-.45	0.00	.49	0.00	-19.99
4.00	0.00	.01	0.00	-.44	0.00	.55	0.00	-21.02
4.20	0.00	.00	0.00	-.42	0.00	.61	0.00	-22.05
4.40	0.00	-.01	0.00	-.41	0.00	.67	0.00	-23.07
4.60	0.00	-.02	0.00	-.40	0.00	.74	0.00	-24.08
4.80	0.00	-.03	0.00	-.39	0.00	.81	0.00	-25.08
5.00	0.00	-.04	0.00	-.37	0.00	.89	0.00	-26.07
5.20	0.00	-.05	0.00	-.36	0.00	.97	0.00	-27.06
5.40	0.00	-.06	0.00	-.35	0.00	1.06	0.00	-28.04
5.60	0.00	-.06	0.00	-.34	0.00	1.15	0.00	-29.01
5.80	0.00	-.07	0.00	-.33	0.00	1.24	0.00	-29.97
6.00	0.00	-.08	0.00	-.32	0.00	1.35	0.00	-30.92
6.20	0.00	-.09	0.00	-.31	0.00	1.45	0.00	-31.87
6.40	0.00	-.09	0.00	-.31	0.00	1.57	0.00	-32.80
6.60	0.00	-.10	0.00	-.30	0.00	1.69	0.00	-33.72
6.80	0.00	-.10	0.00	-.29	0.00	1.81	0.00	-34.64
7.00	0.00	-.11	0.00	-.28	0.00	1.95	0.00	-35.55
7.20	0.00	-.11	0.00	-.28	0.00	2.09	0.00	-36.44
7.40	0.00	-.11	0.00	-.27	0.00	2.24	0.00	-37.33
7.60	0.00	-.11	0.00	-.26	0.00	2.39	0.00	-38.20
7.80	0.00	-.12	0.00	-.26	0.00	2.55	0.00	-39.07
8.00	0.00	-.12	0.00	-.25	0.00	2.72	0.00	-39.93
8.20	0.00	-.12	0.00	-.25	0.00	2.90	0.00	-40.77
8.40	0.00	-.12	0.00	-.24	0.00	3.09	0.00	-41.61
8.60	0.00	-.12	0.00	-.23	0.00	3.28	0.00	-42.43
8.80	0.00	-.12	0.00	-.23	0.00	3.48	0.00	-43.25
9.00	0.00	-.12	0.00	-.23	0.00	3.69	0.00	-44.05
9.20	0.00	-.12	0.00	-.22	0.00	3.91	0.00	-44.85
9.40	0.00	-.12	0.00	-.22	0.00	4.14	0.00	-45.63
9.60	0.00	-.12	0.00	-.21	0.00	4.37	0.00	-46.40
9.80	0.00	-.12	0.00	-.21	0.00	4.61	0.00	-47.16
10.00	0.00	-.12	0.00	-.21	0.00	4.87	0.00	-47.92
10.20	0.00	-.12	0.00	-.20	0.00	5.13	0.00	-48.66
10.40	0.00	-.12	0.00	-.20	0.00	5.40	0.00	-49.39
10.60	0.00	-.12	0.00	-.20	0.00	5.68	0.00	-50.11
10.80	0.00	-.12	0.00	-.19	0.00	5.96	0.00	-50.82
11.00	0.00	-.12	0.00	-.19	0.00	6.26	0.00	-51.52
11.20	0.00	-.12	0.00	-.19	0.00	6.57	0.00	-52.21

11.40	0.00	-.12	0.00	-.19	0.00	6.88	0.00	-52.88
11.60	0.00	-.12	0.00	-.18	0.00	7.20	0.00	-53.55
11.80	0.00	-.12	0.00	-.18	0.00	7.54	0.00	-54.21
12.00	0.00	-.12	0.00	-.18	0.00	7.88	0.00	-54.86
12.20	0.00	-.12	0.00	-.18	0.00	8.23	0.00	-55.49
12.40	0.00	-.12	0.00	-.17	0.00	8.59	0.00	-56.12
12.60	0.00	-.12	0.00	-.17	0.00	8.96	0.00	-56.74
12.80	0.00	-.12	0.00	-.17	0.00	9.34	0.00	-57.35
13.00	0.00	-.12	0.00	-.17	0.00	9.73	0.00	-57.94
13.20	0.00	-.12	0.00	-.17	0.00	10.12	0.00	-58.53
13.40	0.00	-.12	0.00	-.17	0.00	10.53	0.00	-59.11
13.60	0.00	-.12	0.00	-.16	0.00	10.95	0.00	-59.67
13.80	0.00	-.12	0.00	-.16	0.00	11.37	0.00	-60.23
14.00	0.00	-.12	0.00	-.16	0.00	11.81	0.00	-60.78
14.20	0.00	-.12	0.00	-.16	0.00	12.25	0.00	-61.32
14.40	0.00	-.12	0.00	-.16	0.00	12.70	0.00	-61.85
14.60	0.00	-.12	0.00	-.16	0.00	13.17	0.00	-62.37
14.80	0.00	-.12	0.00	-.16	0.00	13.64	0.00	-62.88
15.00	0.00	-.12	0.00	-.16	0.00	14.12	0.00	-63.38
15.20	0.00	-.12	0.00	-.16	0.00	14.61	0.00	-63.87
15.40	0.00	-.12	0.00	-.15	0.00	15.11	0.00	-64.36
15.60	0.00	-.12	0.00	-.15	0.00	15.62	0.00	-64.83
15.80	0.00	-.12	0.00	-.15	0.00	16.14	0.00	-65.30
16.00	0.00	-.12	0.00	-.15	0.00	16.67	0.00	-65.75
16.20	0.00	-.12	0.00	-.15	0.00	17.20	0.00	-66.20
16.40	0.00	-.12	0.00	-.15	0.00	17.75	0.00	-66.64
16.60	0.00	-.12	0.00	-.15	0.00	18.31	0.00	-67.07
16.80	0.00	-.12	0.00	-.15	0.00	18.87	0.00	-67.50
17.00	0.00	-.12	0.00	-.15	0.00	19.45	0.00	-67.91
17.20	0.00	-.12	0.00	-.15	0.00	20.03	0.00	-68.32
17.40	0.00	-.12	0.00	-.15	0.00	20.63	0.00	-68.72
17.60	0.00	-.12	0.00	-.15	0.00	21.23	0.00	-69.11
17.80	0.00	-.12	0.00	-.15	0.00	21.85	0.00	-69.50
18.00	0.00	-.12	0.00	-.15	0.00	22.47	0.00	-69.88
18.20	0.00	-.12	0.00	-.15	0.00	23.10	0.00	-70.25
18.40	0.00	-.12	0.00	-.15	0.00	23.74	0.00	-70.61
18.60	0.00	-.12	0.00	-.15	0.00	24.39	0.00	-70.96
18.80	0.00	-.13	0.00	-.15	0.00	25.06	0.00	-71.31
19.00	0.00	-.13	0.00	-.15	0.00	25.73	0.00	-71.65
19.20	0.00	-.13	0.00	-.15	0.00	26.41	0.00	-71.99
19.40	0.00	-.13	0.00	-.15	0.00	27.09	0.00	-72.31
19.60	0.00	-.13	0.00	-.15	0.00	27.79	0.00	-72.63
19.80	0.00	-.13	0.00	-.15	0.00	28.50	0.00	-72.95
20.00	0.00	-.13	0.00	-.15	0.00	29.22	0.00	-73.25
20.20	0.00	-.13	0.00	-.15	0.00	29.95	0.00	-73.56
20.40	0.00	-.13	0.00	-.15	0.00	30.68	0.00	-73.85
20.60	0.00	-.13	0.00	-.15	0.00	31.43	0.00	-74.14
20.80	0.00	-.13	0.00	-.15	0.00	32.19	0.00	-74.42
21.00	0.00	-.13	0.00	-.15	0.00	32.95	0.00	-74.70
21.20	0.00	-.13	0.00	-.15	0.00	33.73	0.00	-74.97
21.40	0.00	-.13	0.00	-.15	0.00	34.51	0.00	-75.24
21.60	0.00	-.13	0.00	-.15	0.00	35.30	0.00	-75.50
21.80	0.00	-.13	0.00	-.15	0.00	36.11	0.00	-75.75
22.00	0.00	-.13	0.00	-.15	0.00	36.92	0.00	-76.00
22.20	0.00	-.13	0.00	-.15	0.00	37.74	0.00	-76.24
22.40	0.00	-.13	0.00	-.15	0.00	38.58	0.00	-76.48
22.60	0.00	-.13	0.00	-.15	0.00	39.42	0.00	-76.71
22.80	0.00	-.13	0.00	-.15	0.00	40.27	0.00	-76.94
23.00	0.00	-.14	0.00	-.15	0.00	41.13	0.00	-77.16
23.20	0.00	-.14	0.00	-.15	0.00	42.00	0.00	-77.38
23.40	0.00	-.14	0.00	-.15	0.00	42.89	0.00	-77.60
23.60	0.00	-.14	0.00	-.15	0.00	43.78	0.00	-77.80
23.80	0.00	-.14	0.00	-.15	0.00	44.68	0.00	-78.01
24.00	0.00	-.14	0.00	-.15	0.00	45.59	0.00	-78.21
24.20	0.00	-.14	0.00	-.15	0.00	46.51	0.00	-78.40
24.40	0.00	-.14	0.00	-.15	0.00	47.44	0.00	-78.59

20000 POUND BUOYANT RISE (NO RECOVERY)

Initial Pitch Angle = 89 degrees
Initial Pitch Rate = -0.5 degrees/second

RUN NUMBER 2

x_G = -1.5 feet

TIME IN SEC	SPEED IN KNOTS	U IN FT/SEC	V IN FT/SEC	W IN FT/SEC	REVS PER MINUTE	STN PLN DEFLECN IN DEG	BOW PLN DEFLECN IN DEG	RUDDER DEFLECN IN DEG	DEPTH IN FEET	PITCH ANGLE IN DEG	ROLL ANGLE IN DEG	HEADING ANGLE IN DEG	WEIGHT CHANGE THOU LB	DISTANCE TRAVELED IN FEET	DEPTH OF BOW IN FEET
0.00	.01	.02	-0.00	-0.00	.02	0.00	0.00	0.00	5000.00	89.00	0.00	0.00	0.00	0.00	4970.50
.20	.34	1.12	0.00	-.01	.02	0.00	0.00	0.00	4999.94	88.90	0.00	0.00	0.00	.00	4970.45
.40	.99	2.22	0.00	-.02	.02	0.00	0.00	0.00	4999.66	88.81	0.00	0.00	0.00	.00	4970.17
.60	1.64	3.33	0.00	-.03	.02	0.00	0.00	0.00	4999.16	88.72	0.00	0.00	0.00	.01	4969.67
.80	2.29	4.43	0.00	-.04	.02	0.00	0.00	0.00	4998.44	88.64	0.00	0.00	0.00	.02	4968.95
1.00	2.95	5.52	0.00	-.06	.02	0.00	0.00	0.00	4997.50	88.56	0.00	0.00	0.00	.03	4968.01
1.20	3.60	6.62	0.00	-.07	.02	0.00	0.00	0.00	4996.34	88.49	0.00	0.00	0.00	.05	4966.85
1.40	4.24	7.71	0.00	-.09	.02	0.00	0.00	0.00	4994.96	88.43	0.00	0.00	0.00	.07	4965.48
1.60	4.89	8.80	0.00	-.10	.02	0.00	0.00	0.00	4993.37	88.38	0.00	0.00	0.00	.10	4963.88
1.80	5.54	9.89	0.00	-.11	.02	0.00	0.00	0.00	4991.55	88.34	0.00	0.00	0.00	.13	4962.06
2.00	6.18	10.98	0.00	-.13	.02	0.00	0.00	0.00	4989.52	88.30	0.00	0.00	0.00	.16	4960.03
2.20	6.82	12.05	0.00	-.14	.02	0.00	0.00	0.00	4987.27	88.28	0.00	0.00	0.00	.20	4957.78
2.40	7.46	13.13	0.00	-.15	.02	0.00	0.00	0.00	4984.81	88.25	0.00	0.00	0.00	.25	4955.32
2.60	8.09	14.20	0.00	-.16	.02	0.00	0.00	0.00	4982.13	88.24	0.00	0.00	0.00	.30	4952.64
2.80	8.72	15.26	0.00	-.18	.02	0.00	0.00	0.00	4979.23	88.22	0.00	0.00	0.00	.36	4949.75
3.00	9.35	16.32	0.00	-.19	.02	0.00	0.00	0.00	4976.13	88.22	0.00	0.00	0.00	.42	4946.64
3.20	9.98	17.38	0.00	-.20	.02	0.00	0.00	0.00	4972.81	88.21	0.00	0.00	0.00	.48	4943.33
3.40	10.60	18.43	0.00	-.20	.02	0.00	0.00	0.00	4969.28	88.21	0.00	0.00	0.00	.55	4939.80
3.60	11.22	19.47	0.00	-.21	.02	0.00	0.00	0.00	4965.55	88.21	0.00	0.00	0.00	.63	4936.06
3.80	11.83	20.50	0.00	-.22	.02	0.00	0.00	0.00	4961.60	88.20	0.00	0.00	0.00	.71	4932.12
4.00	12.45	21.53	0.00	-.22	.02	0.00	0.00	0.00	4957.45	88.20	0.00	0.00	0.00	.80	4927.96
4.20	13.05	22.55	0.00	-.23	.02	0.00	0.00	0.00	4953.09	88.20	0.00	0.00	0.00	.89	4923.61
4.40	13.65	23.57	0.00	-.23	.02	0.00	0.00	0.00	4948.53	88.20	0.00	0.00	0.00	.99	4919.05
4.60	14.25	24.57	0.00	-.24	.02	0.00	0.00	0.00	4943.77	88.19	0.00	0.00	0.00	1.09	4914.28
4.80	14.85	25.57	0.00	-.24	.02	0.00	0.00	0.00	4938.80	88.18	0.00	0.00	0.00	1.20	4909.32
5.00	15.44	26.56	0.00	-.24	.02	0.00	0.00	0.00	4933.64	88.17	0.00	0.00	0.00	1.31	4904.16
5.20	16.02	27.55	0.00	-.25	.02	0.00	0.00	0.00	4928.28	88.16	0.00	0.00	0.00	1.44	4898.80
5.40	16.60	28.52	0.00	-.25	.02	0.00	0.00	0.00	4922.72	88.15	0.00	0.00	0.00	1.57	4893.24
5.60	17.17	29.49	0.00	-.25	.02	0.00	0.00	0.00	4916.97	88.13	0.00	0.00	0.00	1.70	4887.49
5.80	17.74	30.44	0.00	-.25	.02	0.00	0.00	0.00	4911.03	88.12	0.00	0.00	0.00	1.85	4881.54
6.00	18.31	31.39	0.00	-.25	.02	0.00	0.00	0.00	4904.89	88.10	0.00	0.00	0.00	2.00	4875.41
6.20	18.87	32.33	0.00	-.25	.02	0.00	0.00	0.00	4898.57	88.07	0.00	0.00	0.00	2.16	4869.09
6.40	19.42	33.26	0.00	-.25	.02	0.00	0.00	0.00	4892.06	88.05	0.00	0.00	0.00	2.33	4862.58
6.60	19.97	34.18	0.00	-.25	.02	0.00	0.00	0.00	4885.36	88.03	0.00	0.00	0.00	2.51	4855.88
6.80	20.51	35.09	0.00	-.25	.02	0.00	0.00	0.00	4878.48	88.00	0.00	0.00	0.00	2.69	4849.00
7.00	21.04	35.99	0.00	-.25	.02	0.00	0.00	0.00	4871.42	87.97	0.00	0.00	0.00	2.89	4841.94
7.20	21.57	36.88	0.00	-.25	.02	0.00	0.00	0.00	4864.18	87.94	0.00	0.00	0.00	3.10	4834.70
7.40	22.10	37.76	0.00	-.25	.02	0.00	0.00	0.00	4856.77	87.91	0.00	0.00	0.00	3.31	4827.28
7.60	22.62	38.64	0.00	-.25	.02	0.00	0.00	0.00	4849.17	87.88	0.00	0.00	0.00	3.54	4819.69
7.80	23.13	39.50	0.00	-.25	.02	0.00	0.00	0.00	4841.41	87.85	0.00	0.00	0.00	3.78	4811.93
8.00	23.64	40.35	0.00	-.25	.02	0.00	0.00	0.00	4833.47	87.82	0.00	0.00	0.00	4.03	4803.99
8.20	24.14	41.19	0.00	-.25	.02	0.00	0.00	0.00	4825.36	87.79	0.00	0.00	0.00	4.29	4795.88
8.40	24.63	42.02	0.00	-.25	.02	0.00	0.00	0.00	4817.08	87.75	0.00	0.00	0.00	4.56	4787.61
8.60	25.12	42.84	0.00	-.25	.02	0.00	0.00	0.00	4808.64	87.72	0.00	0.00	0.00	4.84	4779.17
8.80	25.61	43.65	0.00	-.25	.02	0.00	0.00	0.00	4800.04	87.68	0.00	0.00	0.00	5.13	4770.56
9.00	26.08	44.45	0.00	-.25	.02	0.00	0.00	0.00	4791.27	87.65	0.00	0.00	0.00	5.44	4761.80
9.20	26.55	45.24	0.00	-.25	.02	0.00	0.00	0.00	4782.35	87.62	0.00	0.00	0.00	5.76	4752.88
9.40	27.02	46.02	0.00	-.25	.02	0.00	0.00	0.00	4773.27	87.58	0.00	0.00	0.00	6.09	4743.80
9.60	27.47	46.79	0.00	-.25	.02	0.00	0.00	0.00	4764.03	87.55	0.00	0.00	0.00	6.43	4734.56
9.80	27.93	47.54	0.00	-.25	.02	0.00	0.00	0.00	4754.65	87.51	0.00	0.00	0.00	6.78	4725.17
10.00	28.37	48.29	0.00	-.25	.02	0.00	0.00	0.00	4745.11	87.48	0.00	0.00	0.00	7.15	4715.63
10.20	28.81	49.03	0.00	-.25	.02	0.00	0.00	0.00	4735.42	87.44	0.00	0.00	0.00	7.53	4705.95
10.40	29.24	49.75	0.00	-.25	.02	0.00	0.00	0.00	4725.58	87.41	0.00	0.00	0.00	7.92	4696.11
10.60	29.67	50.47	0.00	-.25	.02	0.00	0.00	0.00	4715.61	87.37	0.00	0.00	0.00	8.32	4686.14
10.80	30.09	51.17	0.00	-.25	.02	0.00	0.00	0.00	4705.49	87.34	0.00	0.00	0.00	8.74	4676.02
11.00	30.50	51.87	0.00	-.25	.02	0.00	0.00	0.00	4695.23	87.30	0.00	0.00	0.00	9.16	4665.76
11.20	30.91	52.55	0.00	-.25	.02	0.00	0.00	0.00	4684.83	87.27	0.00	0.00	0.00	9.61	4655.36

11.40	31.31	53.23	0.00	-.25	.02	0.00	0.00	0.00	4674.29	87.24	0.00	0.00	0.00	10.06	4644.83
11.60	31.71	53.89	0.00	-.25	.02	0.00	0.00	0.00	4663.62	87.20	0.00	0.00	0.00	10.53	4634.16
11.80	32.10	54.54	0.00	-.25	.02	0.00	0.00	0.00	4652.82	87.17	0.00	0.00	0.00	11.01	4623.36
12.00	32.48	55.18	0.00	-.25	.02	0.00	0.00	0.00	4641.89	87.13	0.00	0.00	0.00	11.50	4612.43
12.20	32.86	55.82	0.00	-.25	.02	0.00	0.00	0.00	4630.84	87.10	0.00	0.00	0.00	12.01	4601.38
12.40	33.23	56.44	0.00	-.25	.02	0.00	0.00	0.00	4619.65	87.06	0.00	0.00	0.00	12.53	4590.19
12.60	33.60	57.05	0.00	-.25	.02	0.00	0.00	0.00	4608.35	87.03	0.00	0.00	0.00	13.06	4578.89
12.80	33.96	57.66	0.00	-.25	.02	0.00	0.00	0.00	4596.92	86.99	0.00	0.00	0.00	13.61	4567.46
13.00	34.31	58.25	0.00	-.25	.02	0.00	0.00	0.00	4585.37	86.96	0.00	0.00	0.00	14.16	4555.91
13.20	34.66	58.83	0.00	-.25	.02	0.00	0.00	0.00	4573.71	86.93	0.00	0.00	0.00	14.74	4544.25
13.40	35.00	59.40	0.00	-.25	.02	0.00	0.00	0.00	4561.93	86.89	0.00	0.00	0.00	15.32	4532.47
13.60	35.34	59.97	0.00	-.25	.02	0.00	0.00	0.00	4550.03	86.86	0.00	0.00	0.00	15.92	4520.58
13.80	35.67	60.52	0.00	-.25	.02	0.00	0.00	0.00	4538.03	86.82	0.00	0.00	0.00	16.53	4508.57
14.00	35.99	61.06	0.00	-.25	.02	0.00	0.00	0.00	4525.91	86.79	0.00	0.00	0.00	17.16	4496.46
14.20	36.31	61.60	0.00	-.25	.02	0.00	0.00	0.00	4513.69	86.75	0.00	0.00	0.00	17.79	4484.24
14.40	36.63	62.12	0.00	-.25	.02	0.00	0.00	0.00	4501.36	86.72	0.00	0.00	0.00	18.45	4471.91
14.60	36.94	62.64	0.00	-.25	.02	0.00	0.00	0.00	4488.93	86.69	0.00	0.00	0.00	19.11	4459.48
14.80	37.24	63.15	0.00	-.25	.02	0.00	0.00	0.00	4476.39	86.65	0.00	0.00	0.00	19.79	4446.94
15.00	37.54	63.64	0.00	-.25	.02	0.00	0.00	0.00	4463.76	86.62	0.00	0.00	0.00	20.48	4434.31
15.20	37.83	64.13	0.00	-.25	.02	0.00	0.00	0.00	4451.02	86.58	0.00	0.00	0.00	21.19	4421.57
15.40	38.11	64.61	0.00	-.25	.02	0.00	0.00	0.00	4438.19	86.55	0.00	0.00	0.00	21.90	4408.74
15.60	38.40	65.08	0.00	-.25	.02	0.00	0.00	0.00	4425.27	86.52	0.00	0.00	0.00	22.64	4395.82
15.80	38.67	65.55	0.00	-.25	.02	0.00	0.00	0.00	4412.25	86.48	0.00	0.00	0.00	23.38	4382.80
16.00	38.94	66.00	0.00	-.25	.02	0.00	0.00	0.00	4399.14	86.45	0.00	0.00	0.00	24.14	4369.69
16.20	39.21	66.45	0.00	-.25	.02	0.00	0.00	0.00	4385.94	86.41	0.00	0.00	0.00	24.91	4356.49
16.40	39.47	66.88	0.00	-.25	.02	0.00	0.00	0.00	4372.65	86.38	0.00	0.00	0.00	25.69	4343.21
16.60	39.73	67.31	0.00	-.25	.02	0.00	0.00	0.00	4359.27	86.34	0.00	0.00	0.00	26.49	4329.83
16.80	39.98	67.73	0.00	-.25	.02	0.00	0.00	0.00	4345.81	86.31	0.00	0.00	0.00	27.30	4316.37
17.00	40.23	68.15	0.00	-.25	.02	0.00	0.00	0.00	4332.27	86.28	0.00	0.00	0.00	28.13	4302.83
17.20	40.47	68.55	0.00	-.25	.02	0.00	0.00	0.00	4318.65	86.24	0.00	0.00	0.00	28.97	4289.21
17.40	40.71	68.95	0.00	-.25	.02	0.00	0.00	0.00	4304.94	86.21	0.00	0.00	0.00	29.82	4275.51
17.60	40.94	69.34	0.00	-.25	.02	0.00	0.00	0.00	4291.16	86.17	0.00	0.00	0.00	30.68	4261.73
17.80	41.17	69.72	0.00	-.26	.02	0.00	0.00	0.00	4277.30	86.14	0.00	0.00	0.00	31.56	4247.87
18.00	41.39	70.09	0.00	-.26	.02	0.00	0.00	0.00	4263.37	86.10	0.00	0.00	0.00	32.45	4233.94
18.20	41.61	70.46	0.00	-.26	.02	0.00	0.00	0.00	4249.36	86.07	0.00	0.00	0.00	33.36	4219.93
18.40	41.82	70.82	0.00	-.26	.02	0.00	0.00	0.00	4235.28	86.03	0.00	0.00	0.00	34.28	4205.85
18.60	42.04	71.17	0.00	-.26	.02	0.00	0.00	0.00	4221.13	86.00	0.00	0.00	0.00	35.21	4191.70
18.80	42.24	71.52	0.00	-.26	.02	0.00	0.00	0.00	4206.91	85.96	0.00	0.00	0.00	36.16	4177.48
19.00	42.44	71.86	0.00	-.26	.02	0.00	0.00	0.00	4192.62	85.93	0.00	0.00	0.00	37.12	4163.19
19.20	42.64	72.19	0.00	-.26	.02	0.00	0.00	0.00	4178.26	85.89	0.00	0.00	0.00	38.09	4148.84
19.40	42.84	72.51	0.00	-.26	.02	0.00	0.00	0.00	4163.84	85.86	0.00	0.00	0.00	39.07	4134.42
19.60	43.03	72.83	0.00	-.26	.02	0.00	0.00	0.00	4149.36	85.82	0.00	0.00	0.00	40.07	4119.94
19.80	43.21	73.14	0.00	-.26	.02	0.00	0.00	0.00	4134.81	85.78	0.00	0.00	0.00	41.08	4105.39
20.00	43.40	73.45	0.00	-.26	.02	0.00	0.00	0.00	4120.20	85.75	0.00	0.00	0.00	42.11	4090.78
20.20	43.58	73.75	0.00	-.27	.02	0.00	0.00	0.00	4105.53	85.71	0.00	0.00	0.00	43.15	4076.12
20.40	43.75	74.04	0.00	-.27	.02	0.00	0.00	0.00	4090.81	85.68	0.00	0.00	0.00	44.20	4061.39
20.60	43.92	74.33	0.00	-.27	.02	0.00	0.00	0.00	4076.02	85.64	0.00	0.00	0.00	45.27	4046.61
20.80	44.09	74.61	0.00	-.27	.02	0.00	0.00	0.00	4061.18	85.61	0.00	0.00	0.00	46.35	4031.77
21.00	44.26	74.89	0.00	-.27	.02	0.00	0.00	0.00	4046.28	85.57	0.00	0.00	0.00	47.44	4016.87
21.20	44.42	75.16	0.00	-.27	.02	0.00	0.00	0.00	4031.33	85.53	0.00	0.00	0.00	48.55	4001.92
21.40	44.58	75.42	0.00	-.27	.02	0.00	0.00	0.00	4016.33	85.50	0.00	0.00	0.00	49.67	3986.92
21.60	44.73	75.68	0.00	-.27	.02	0.00	0.00	0.00	4001.28	85.46	0.00	0.00	0.00	50.80	3971.87
21.80	44.88	75.93	0.00	-.27	.02	0.00	0.00	0.00	3986.17	85.42	0.00	0.00	0.00	51.95	3956.77
22.00	45.03	76.18	0.00	-.28	.02	0.00	0.00	0.00	3971.02	85.38	0.00	0.00	0.00	53.11	3941.61
22.20	45.17	76.42	0.00	-.28	.02	0.00	0.00	0.00	3955.82	85.35	0.00	0.00	0.00	54.28	3926.41
22.40	45.32	76.66	0.00	-.28	.02	0.00	0.00	0.00	3940.57	85.31	0.00	0.00	0.00	55.47	3911.16
22.60	45.46	76.89	0.00	-.28	.02	0.00	0.00	0.00	3925.27	85.27	0.00	0.00	0.00	56.67	3895.87
22.80	45.59	77.12	0.00	-.28	.02	0.00	0.00	0.00	3909.93	85.24	0.00	0.00	0.00	57.89	3880.53
23.00	45.72	77.34	0.00	-.28	.02	0.00	0.00	0.00	3894.54	85.20	0.00	0.00	0.00	59.12	3865.15
23.20	45.85	77.56	0.00	-.28	.02	0.00	0.00	0.00	3879.11	85.16	0.00	0.00	0.00	60.36	3849.72
23.40	45.98	77.77	0.00	-.29	.02	0.00	0.00	0.00	3863.64	85.12	0.00	0.00	0.00	61.61	3834.25
23.60	46.11	77.98	0.00	-.29	.02	0.00	0.00	0.00	3848.13	85.08	0.00	0.00	0.00	62.88	3818.74
23.80	46.23	78.18	0.00	-.29	.02	0.00	0.00	0.00	3832.58	85.04	0.00	0.00	0.00	64.17	3803.19
24.00	46.35	78.38	0.00	-.29	.02	0.00	0.00	0.00	3816.99	85.01	0.00	0.00	0.00	65.46	3787.60
24.20	46.46	78.57	0.00	-.29	.02	0.00	0.00	0.00	3801.35	84.97	0.00	0.00	0.00	66.77	3771.97
24.40	46.58	78.76	0.00	-.29	.02	0.00	0.00	0.00	3785.69	84.93	0.00	0.00	0.00	68.10	3756.30

20000 POUND BUOYANT RISE (NO RECOVERY)

Initial Pitch Angle = 89 degrees
Initial Pitch Rate = -0.5 degrees/second

SECOND PAGE OF OUTPUT FOR RUN 2 x_G = -1.5 feet

TIME IN SEC	P IN DEG/SEC	Q IN DEG/SEC	R IN DEG/SEC	ALFA IN DEGREES	BETA IN DEGREES	X IN FEET	Y IN FEET	DEPTH RATE IN FT/SEC
0.00	0.00	-.50	0.00	0.00	0.00	0.00	0.00	0.00
.20	0.00	-.48	0.00	-.49	0.00	.00	0.00	-.57
.40	0.00	-.45	0.00	-.52	0.00	.00	0.00	-1.67
.60	0.00	-.42	0.00	-.55	0.00	.01	0.00	-2.77
.80	0.00	-.38	0.00	-.58	0.00	.02	0.00	-3.88
1.00	0.00	-.35	0.00	-.60	0.00	.03	0.00	-4.97
1.20	0.00	-.31	0.00	-.62	0.00	.05	0.00	-6.07
1.40	0.00	-.27	0.00	-.64	0.00	.07	0.00	-7.17
1.60	0.00	-.23	0.00	-.65	0.00	.10	0.00	-8.26
1.80	0.00	-.19	0.00	-.66	0.00	.13	0.00	-9.35
2.00	0.00	-.15	0.00	-.66	0.00	.16	0.00	-10.43
2.20	0.00	-.12	0.00	-.67	0.00	.20	0.00	-11.51
2.40	0.00	-.09	0.00	-.67	0.00	.25	0.00	-12.59
2.60	0.00	-.07	0.00	-.66	0.00	.30	0.00	-13.66
2.80	0.00	-.05	0.00	-.66	0.00	.36	0.00	-14.73
3.00	0.00	-.03	0.00	-.65	0.00	.42	0.00	-15.79
3.20	0.00	-.02	0.00	-.64	0.00	.48	0.00	-16.85
3.40	0.00	-.01	0.00	-.63	0.00	.55	0.00	-17.90
3.60	0.00	-.01	0.00	-.62	0.00	.63	0.00	-18.95
3.80	0.00	-.01	0.00	-.61	0.00	.71	0.00	-19.98
4.00	0.00	-.01	0.00	-.60	0.00	.80	0.00	-21.02
4.20	0.00	-.02	0.00	-.58	0.00	.89	0.00	-22.04
4.40	0.00	-.02	0.00	-.57	0.00	.99	0.00	-23.06
4.60	0.00	-.03	0.00	-.55	0.00	1.09	0.00	-24.07
4.80	0.00	-.04	0.00	-.54	0.00	1.20	0.00	-25.07
5.00	0.00	-.05	0.00	-.52	0.00	1.31	0.00	-26.06
5.20	0.00	-.07	0.00	-.51	0.00	1.44	0.00	-27.05
5.40	0.00	-.08	0.00	-.50	0.00	1.57	0.00	-28.03
5.60	0.00	-.09	0.00	-.48	0.00	1.70	0.00	-29.00
5.80	0.00	-.10	0.00	-.47	0.00	1.85	0.00	-29.96
6.00	0.00	-.11	0.00	-.46	0.00	2.00	0.00	-30.91
6.20	0.00	-.12	0.00	-.45	0.00	2.16	0.00	-31.85
6.40	0.00	-.12	0.00	-.43	0.00	2.33	0.00	-32.79
6.60	0.00	-.13	0.00	-.42	0.00	2.51	0.00	-33.71
6.80	0.00	-.14	0.00	-.41	0.00	2.69	0.00	-34.62
7.00	0.00	-.14	0.00	-.40	0.00	2.89	0.00	-35.53
7.20	0.00	-.15	0.00	-.39	0.00	3.10	0.00	-36.42
7.40	0.00	-.15	0.00	-.38	0.00	3.31	0.00	-37.31
7.60	0.00	-.16	0.00	-.37	0.00	3.54	0.00	-38.18
7.80	0.00	-.16	0.00	-.37	0.00	3.78	0.00	-39.05
8.00	0.00	-.16	0.00	-.36	0.00	4.03	0.00	-39.90
8.20	0.00	-.17	0.00	-.35	0.00	4.29	0.00	-40.75
8.40	0.00	-.17	0.00	-.34	0.00	4.56	0.00	-41.58
8.60	0.00	-.17	0.00	-.34	0.00	4.84	0.00	-42.41
8.80	0.00	-.17	0.00	-.33	0.00	5.13	0.00	-43.22
9.00	0.00	-.17	0.00	-.32	0.00	5.44	0.00	-44.02
9.20	0.00	-.17	0.00	-.32	0.00	5.76	0.00	-44.82
9.40	0.00	-.17	0.00	-.31	0.00	6.09	0.00	-45.60
9.60	0.00	-.17	0.00	-.31	0.00	6.43	0.00	-46.37
9.80	0.00	-.17	0.00	-.30	0.00	6.78	0.00	-47.13
10.00	0.00	-.17	0.00	-.30	0.00	7.15	0.00	-47.88
10.20	0.00	-.17	0.00	-.29	0.00	7.53	0.00	-48.62
10.40	0.00	-.17	0.00	-.29	0.00	7.92	0.00	-49.35
10.60	0.00	-.17	0.00	-.28	0.00	8.32	0.00	-50.07
10.80	0.00	-.17	0.00	-.28	0.00	8.74	0.00	-50.78
11.00	0.00	-.17	0.00	-.27	0.00	9.16	0.00	-51.48
11.20	0.00	-.17	0.00	-.27	0.00	9.61	0.00	-52.16

11.40	0.00	-.17	0.00	-.27	0.00	10.06	0.00	-52.84
11.60	0.00	-.17	0.00	-.26	0.00	10.53	0.00	-53.51
11.80	0.00	-.17	0.00	-.26	0.00	11.01	0.00	-54.16
12.00	0.00	-.17	0.00	-.26	0.00	11.50	0.00	-54.81
12.20	0.00	-.17	0.00	-.25	0.00	12.01	0.00	-55.44
12.40	0.00	-.17	0.00	-.25	0.00	12.53	0.00	-56.07
12.60	0.00	-.17	0.00	-.25	0.00	13.06	0.00	-56.68
12.80	0.00	-.17	0.00	-.24	0.00	13.61	0.00	-57.29
13.00	0.00	-.17	0.00	-.24	0.00	14.16	0.00	-57.88
13.20	0.00	-.17	0.00	-.24	0.00	14.74	0.00	-58.47
13.40	0.00	-.17	0.00	-.24	0.00	15.32	0.00	-59.05
13.60	0.00	-.17	0.00	-.24	0.00	15.92	0.00	-59.61
13.80	0.00	-.17	0.00	-.23	0.00	16.53	0.00	-60.17
14.00	0.00	-.17	0.00	-.23	0.00	17.16	0.00	-60.71
14.20	0.00	-.17	0.00	-.23	0.00	17.79	0.00	-61.25
14.40	0.00	-.17	0.00	-.23	0.00	18.45	0.00	-61.78
14.60	0.00	-.17	0.00	-.23	0.00	19.11	0.00	-62.29
14.80	0.00	-.17	0.00	-.22	0.00	19.79	0.00	-62.80
15.00	0.00	-.17	0.00	-.22	0.00	20.48	0.00	-63.30
15.20	0.00	-.17	0.00	-.22	0.00	21.19	0.00	-63.79
15.40	0.00	-.17	0.00	-.22	0.00	21.90	0.00	-64.27
15.60	0.00	-.17	0.00	-.22	0.00	22.64	0.00	-64.75
15.80	0.00	-.17	0.00	-.22	0.00	23.38	0.00	-65.21
16.00	0.00	-.17	0.00	-.22	0.00	24.14	0.00	-65.67
16.20	0.00	-.17	0.00	-.22	0.00	24.91	0.00	-66.11
16.40	0.00	-.17	0.00	-.21	0.00	25.69	0.00	-66.55
16.60	0.00	-.17	0.00	-.21	0.00	26.49	0.00	-66.98
16.80	0.00	-.17	0.00	-.21	0.00	27.30	0.00	-67.40
17.00	0.00	-.17	0.00	-.21	0.00	28.13	0.00	-67.82
17.20	0.00	-.17	0.00	-.21	0.00	28.97	0.00	-68.22
17.40	0.00	-.17	0.00	-.21	0.00	29.82	0.00	-68.62
17.60	0.00	-.17	0.00	-.21	0.00	30.68	0.00	-69.01
17.80	0.00	-.17	0.00	-.21	0.00	31.56	0.00	-69.39
18.00	0.00	-.17	0.00	-.21	0.00	32.45	0.00	-69.76
18.20	0.00	-.17	0.00	-.21	0.00	33.36	0.00	-70.13
18.40	0.00	-.18	0.00	-.21	0.00	34.28	0.00	-70.49
18.60	0.00	-.18	0.00	-.21	0.00	35.21	0.00	-70.84
18.80	0.00	-.18	0.00	-.21	0.00	36.16	0.00	-71.19
19.00	0.00	-.18	0.00	-.21	0.00	37.12	0.00	-71.53
19.20	0.00	-.18	0.00	-.21	0.00	38.09	0.00	-71.86
19.40	0.00	-.18	0.00	-.21	0.00	39.07	0.00	-72.18
19.60	0.00	-.18	0.00	-.21	0.00	40.07	0.00	-72.50
19.80	0.00	-.18	0.00	-.21	0.00	41.08	0.00	-72.81
20.00	0.00	-.18	0.00	-.21	0.00	42.11	0.00	-73.12
20.20	0.00	-.18	0.00	-.21	0.00	43.15	0.00	-73.42
20.40	0.00	-.18	0.00	-.21	0.00	44.20	0.00	-73.71
20.60	0.00	-.18	0.00	-.21	0.00	45.27	0.00	-73.99
20.80	0.00	-.18	0.00	-.21	0.00	46.35	0.00	-74.27
21.00	0.00	-.18	0.00	-.21	0.00	47.44	0.00	-74.55
21.20	0.00	-.18	0.00	-.21	0.00	48.55	0.00	-74.82
21.40	0.00	-.18	0.00	-.21	0.00	49.67	0.00	-75.08
21.60	0.00	-.18	0.00	-.21	0.00	50.80	0.00	-75.34
21.80	0.00	-.19	0.00	-.21	0.00	51.95	0.00	-75.59
22.00	0.00	-.19	0.00	-.21	0.00	53.11	0.00	-75.83
22.20	0.00	-.19	0.00	-.21	0.00	54.28	0.00	-76.07
22.40	0.00	-.19	0.00	-.21	0.00	55.47	0.00	-76.31
22.60	0.00	-.19	0.00	-.21	0.00	56.67	0.00	-76.54
22.80	0.00	-.19	0.00	-.21	0.00	57.89	0.00	-76.76
23.00	0.00	-.19	0.00	-.21	0.00	59.12	0.00	-76.98
23.20	0.00	-.19	0.00	-.21	0.00	60.36	0.00	-77.20
23.40	0.00	-.19	0.00	-.21	0.00	61.61	0.00	-77.41
23.60	0.00	-.19	0.00	-.21	0.00	62.88	0.00	-77.61
23.80	0.00	-.19	0.00	-.21	0.00	64.17	0.00	-77.81
24.00	0.00	-.19	0.00	-.21	0.00	65.46	0.00	-78.01
24.20	0.00	-.19	0.00	-.21	0.00	66.77	0.00	-78.20
24.40	0.00	-.20	0.00	-.21	0.00	68.10	0.00	-78.39

APPENDIX C

EQUATIONS USED IN TRAJECTORY SIMULATION

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EQUATIONS USED IN TRAJECTORY SIMULATION

The non-linear equations used to simulate the vertical plane trajectory of the DOLLY VARDEN are the "Standard Equations of Motion for Submarine Simulation" given in Reference 1. In the present application all terms involving horizontal plane variables (v, r, and p) are zero and the roll angle is zero. In addition, some non-linear vertical plane coefficients were not estimated, and their effect in the equations is neglected. The axial force, normal force, and pitch moment equation are given below where the hydrodynamic coefficients are given in Tables 3 and 5 and X_{uu}' is given by the equation

$$X_{uu}' = (C_T + C_R)\, S_{TOT}/L^2 \tag{C-1}$$

Axial Force

$$m(\dot{u} + wq) - m x_G q^2 + m z_G \dot{q} = \frac{\rho}{2} L^2 X_{uu}' u^2 - (W - B) \sin\theta \tag{C-2}$$

Normal Force

$$\begin{aligned} m(\dot{w} - uq) - m x_G \dot{q} - m z_G q^2 = {} & + \frac{\rho}{2} L^4 Z_{\dot{q}}' \dot{q} + \frac{\rho}{2} L^3 Z_{\dot{w}}' \dot{w} + \frac{\rho}{2} L^3 Z_q' uq \\ & + \frac{\rho}{2} L^2 \left[Z_w' uw + Z_{w|w|}' w|w| \right] + (W - B) \cos\theta \end{aligned} \tag{C-3}$$

Pitch Moment

$$
\begin{aligned}
I_y \dot{q} + m z_G (\dot{u} + wq) - m x_G (\dot{w} - uq) = \\
+ \tfrac{\rho}{2} L^5 M'_{\dot{q}} \dot{q} + \tfrac{\rho}{2} L^4 M'_{\dot{w}} \dot{w} + \tfrac{\rho}{2} L^4 M'_{q} uq \\
+ \tfrac{\rho}{2} L^3 \left[M'_{w} uw + M'_{w|w|} w|w| \right] \\
- (x_G W - x_B B) \cos\theta - (z_G W - z_B B) \sin\theta
\end{aligned}
\tag{C-4}
$$

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